

**MINISTRY OF HEALTH
OF
REPUBLIC OF MALDIVES**

**RESPONSIVE COVID-19 VACCINATION FOR RECOVERY
PROJECT UNDER THE ASIA PACIFIC VACCINE ACCESS
FACILITY (APVAX)**

VOLUME – 3

**GENERAL, SPECIAL SPECIFICATIONS & SOIL
INVESTIGATION REPORT**

FOR

**CONSTRUCTION OF THE CENTRAL COLD CHAIN FACILITY
BUILDING WITH CLIMATE FRIENDLY DESIGNS AT HULHUMALE, LOT
11766**

Employer: Ministry of Health,
Republic of Maldives

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SOIL INVESTIGATION REPORT

GENERAL SPECIFICATIONS

The Contractor shall perform the works in compliance with the general specifications. Wherever special specifications have been given, the special specification shall override the general specifications. Where there is an ambiguity between general specifications, special specifications, drawings & BOQ, the Contractor shall notify the Engineer for a decision before ordering the materials & before proceeding with work.

1. PRELIMINARIES

1.1 Standard and Codes

- 1.1.1 The Contractor shall, perform the Works in compliance with all regulations, standard specifications or statutes of the Government of Maldives unless otherwise conform to this specification.
- 1.1.2 The current British Standard Specifications and Codes of Practice shall apply to and form part of these specifications unless otherwise specified in respect of all materials and works to which they have application.
- 1.1.3 In various places throughout this specification and the Bills of Quantities reference is made to the Standards, Specifications and Bye-Laws issued by the British Standards Institution and other similar organizations. These references shall in every case be deemed to include the latest edition or issue of such Standards, Specifications and By Laws including all revisions, amendments and addenda subsequently issued. Where materials are not specified to be to a particular British Standard and a British Standard exists in respect of such materials, then the materials shall in all respects comply with the relevant and current British Standard. In such cases where British Standards do not exist, the materials used shall be of the best type available and shall generally be to the Engineer's satisfaction.

1.2 Drawings and Specifications

- 1.2.1 Drawings and Specifications are intended to complement each other, so that if anything is shown on the Drawings, but not mentioned in the specifications or vice versa, it is to be furnished and built as though specifically set forth in all three. If any discrepancies, errors, ambiguities or omissions occur in the Drawings or Specifications, the same shall be referred to the Engineer before proceeding with the Works, and the Engineer decision on such discrepancies, errors, ambiguities or omissions shall be final.
- 1.2.2 In addition to the Drawings and Specifications attached hereto, the Engineer will during the progress of the Works furnish additional Drawings, Specifications, and instructions as may be necessary, in the opinion of the Engineer for the purpose of the proper and adequate execution and maintenance of the Works, and the Contractor shall make his work conform. Such drawings and instructions shall be deemed to be part of the Contract Documents.

1.3 Transportation to the Site

- 1.3.1 The Contractor shall provide all necessary transport, handling and storage of all materials, components and the like to their points of installation on site including transport to and from storage. The Contractor shall provide all necessary transport of labour to and from the site.

1.4 Schedule and Execution Plan

- 1.4.1 The Contractor shall prepare and submit to the Engineer for approval
- a. The construction schedule and
 - b. Detailed Method statement for total construction works.
 - c. An execution plan of temporary facilities, stockyards, etc., before the start of the Works.

1.5 Repairing and Correction

- 1.5.1 Any breakage(s) or defect(s) of existing buildings, road utilities, or part(s) of them caused by the Works including transportation for the works shall be repaired or corrected by the Contractor with his responsibility.

1.6 Workmanship and Materials

- 1.6.1 All workmanship shall be of the best standard. All goods and materials to be incorporated in the Works must be new, unused, of the most recent or current models and incorporate all recent improvements in design and materials unless provided otherwise in the contract.
- 1.6.2 The Contractor shall submit for the approval of the Engineer a list of names and addresses of the manufacturers and trademarks or names of all the various types of materials and goods he propose to use in the Works. The list shall include reference to the specifications clause or article to which the materials and goods apply.
- 1.6.3 Materials shall be obtained from approved sources and used in accordance with the manufacturer's printed instructions. In the absence of a specification all materials shall comply with a relevant standard. The Engineer shall order the removal of any materials, which he has not approved.
- 1.6.4 No orders for materials and goods shall be placed until approval has been obtained for the materials and goods from the Engineer.
- 1.6.5 The Contractor shall note that it is his responsibility to include in his price for the cost of the materials and products as specified and no adjustment will be allowed should the Engineer reject the alternatives.

1.7 Obvious Work

- 1.7.1 Where an item of work is obviously required for the type of work being undertaken then it shall be deemed to have been included even though the

item is not specifically mentioned or shown in the Drawings or Specifications.

1.8 Protection

- 1.8.1 The Contractor shall cover up and protect the Works and adjoining properties from the weather and from Any loss or damage caused by weather, carelessness or lack of skill of workers, accident or otherwise shall be of such property that is affected. He shall provide all necessary dust sheets, barriers and guard rails and clear away same at completion.
- 1.8.2 The Contractor shall take all reasonable and proper steps for the protection of all places on or about the Works, which may be dangerous to his workmen or any other persons or to traffic. The Contractor shall provide and maintain warning signs, red warning lamps and barricades as necessary in all such places.
- 1.8.3 The work shall be suspended for such time as may be directed and/or approve by the Engineer if the specified quality of work is difficult to maintain during inclement weather.

1.9 Scaffolding

- 1.9.1 The Contractor shall provide, erect, maintain, dismantle and clear away at completion proper and adequate including that required for subcontractor and suppliers. Putlog holes shall be made good to match the adjacent surface as the scaffolding is dismantled.
- 1.9.2 The Contractor shall be responsible for all safety precautions in connection with the scaffolding including the provision of all bracing, scaffold boards, toe boards and the like and for entire sufficiency for the work.
- 1.9.3 If in the Engineer's opinion scaffolding is considered dangerous then the Contractor shall rectify the same at his own expense. All work utilizing scaffold shall be halted until the scaffold is corrected all to the Engineer's written approval.

1.10 Construction Machinery, Plants and Equipment's

- 1.10.1 All necessary construction machines shall be provided and maintained by the Contractor and shall be approved by the Engineer.
- 1.10.2 If cranes or any other type of plant which places any load on the structure are proposed, all details of such plant shall be submitted to the Engineer for approval before the work is actually commenced. If approved by the Engineer and contractually acceptable, permission may be given for the structure to be strengthened, in order to carry out loads, and the Contractor shall be responsible for any resulting additional costs.
- 1.10.3 The Contractor shall be responsible for making good to the satisfaction of the Engineer any damage to the permanent structure that may be caused by his plant and equipment.

1.11 Samples

- 1.11.1 The Contractor shall furnish for the approval with reasonable promptness, all samples as directed by the Engineer. The Engineer shall check and approve such materials with reasonable promptness only for conformance with the design concept of the Works and for compliance with the information given in the Contract Document. The Work shall be in accordance with the approved samples
- 1.11.2 All samples shall be delivered to the Engineer's office with all charges in connection therewith paid by the Contractor and deemed to be included in the Contract Price.
- 1.11.3 Duplicate final approved samples, in addition to any required for the Contractor's use, shall be furnished to the Engineer, one for office use and one for the site.
- 1.11.4 Samples shall be furnished so as not to delay fabrication, allowing the Engineer reasonable time for consideration of the sample submitted.
- 1.11.5 Each sample shall be properly labeled with the name and quality of the material, manufacturer's name, name of project, the contractor's name and date of submission, and the specification clause to which the sample refers.
- 1.11.6 All samples submitted to the Engineer for approval shall be accompanied by necessary test reports, guarantees and warranties.

1.12 Ordering Materials

- 1.12.1 The Bills of Quantities shall not be used as a basis for ordering materials and the Contractor is entirely responsible for assessing the quantities of materials to be ordered.
- 1.12.2 Upon receipt of the Engineer's order to commence the Works, the Contractor shall immediately place orders for all required materials and will be held responsible for any delays occurring due to late placing of such orders.
- 1.12.3 Prior to finalizing material orders, the Contractor shall advise the Employer and await the Employer's written approval to complete the same.
- 1.12.4 The Contractor shall pay all expenses, taxes and dues etc. incurred on the procurement of materials from abroad

1.13 Water and Electricity for the Works

- 1.13.1 The Contractor shall make all necessary arrangements and provide all water for the proper execution of the Works, together with all transport, temporary plumbing, storage and distribution, pay all charges and alter, adept and maintain temporary work as necessary and remove and make good at completion.

- 1.13.2 The Contractor shall make all necessary arrangements and provide all artificial lighting and power (maintain a generator if necessary) for the proper execution and security of the Works and its protection, with all meters, temporary wiring and fittings, pay all charges and alter adapt and maintain the temporary work as necessary and remove and make good at completion.

1.14 Site Offices for Contractor

- 1.14.1 The Contractor shall provide maintain and clear away on completion of the Contract all necessary site offices, canteens, messing and welfare facilities, temporary buildings, toilets and the like for all site staff employed by the Contractor and required by subcontractors and suppliers.
- 1.14.2 The offices shall be open at all normal working hours to receive instructions, notices and other communications.
- 1.14.3 The Contractor shall obtain the approval of the Engineer of the proposed site layout, type and drainage arrangement of all the buildings prior to erection of same. All buildings shall be supplied and maintained in good condition and of neat appearance; all maintenance to same as instructed by the Engineer shall be carried out at the Contractor's expense.
- 1.14.4 Under no circumstances shall overnight accommodation be permitted on Site except for the site watchman in carrying out his duties.

1.15 Contractor's Site Area

- 1.15.1 Throughout the period of the Contract the Contractor shall maintain the area of his operation within the limits of the Site in a clean, tidy and safe condition by arranging materials and the like in an orderly manner. All rubbish, debris, waste materials and the like shall be systematically cleared from the Site as it accumulates.
- 1.15.2 The Contractor shall take all steps necessary as directed by the Engineer to minimize or eliminate dust, noise or any other nuisance, which may occur. Plant emitting dust, smoke, excessive noise or other nuisance shall not be permitted.
- 1.15.3 Under no circumstances shall overnight accommodation be permitted on Site except for the site watchman in carrying out his duties.

1.16 Site Progress Meetings

- 1.16.1 During the course of the Works, progress meetings shall be held at fortnightly intervals for the purpose of coordinating the Contractor's works and to ensure that full compliance is maintained.
- 1.16.2 Minutes of such meetings should be recorded; copies will be distributed to all persons concerned and full effect shall be given to all instructions contained therein.
- 1.16.3 Prior to such meetings the Contractor shall give to the Engineer's Representative details in writing of that portion of the Works he proposes to

construct during the coming two weeks with details of the plant and method he proposes to employ. These proposals shall be discussed at the meeting and no work based on such proposals shall proceed without the approval of the Engineer's Representative.

- 1.16.4 The Contractor shall submit all reports as instructed by the Engineer in connection with progress meetings and the day to day management of the Works.

1.17 Progress Photographs

- 1.17.1 The Contractor shall supply once a month, at the time of submitting his monthly report, twelve photographs in digital form showing the progress of the Works. The photographs shall be included into the monthly report. In addition, the contractor shall submit to the Engineer additional photographs if instructed by the Engineer. The Engineer may direct the times and position from which the photographs are to be taken.
- 1.17.2 The Contractor shall supply once a month online progress reports to the engineer prior to submission of the hardcopy of the same.
- 1.17.3 The contractor is to make arrangements to have necessary number of CCTV cameras to cover the construction activities at site enabling the engineer to view the same online.

1.18 Setting Out

- 1.18.1 The Contractor shall be responsible for accurately setting out the Works to the specified positions, dimension, levels and Building Lines and also checking the site surveys for dimensional and level accuracy and reporting any discrepancies before building work commences.
- 1.18.2 The Contractor shall provide the Engineer with all facilities, equipment and labour to enable him to check the setting out and levels of the Works at all times. The checking of any setting out point, line or level by the Engineer shall not in any way relieve the Contractor of his responsibility
- 1.18.3 All setting out points, benchmarks, site rails, pegs and other survey points shall be clearly marked and protected from damage or disturbance during the execution of the Works

1.19 Bill boards

- 1.19.1 The Contractor shall provide and maintain one billboard for the Site consisting of a plastic board panel of size not more than 2.4m x1.2m (2.88m²) supported 2.5m above the ground with steel angle framing or similar material and fixed in concrete foundations.
- 1.19.2 The board shall have the following written in both Dhivehi and English (letter height not to exceed 100mm) by a skilled sign writer:
- The name of Project***
- The name of Employer***

The name and address of Engineer (Lead Consultant)

The name and address of National Sub-Consultants

The name and address of Contractor

1.19.3 A scaled layout shall be prepared and submitted for the Engineer's approval before fabrication.

1.19.4 No advertising material other than the above will be permitted.

1.19.5 The location and layout of Sub-Contractors or Manufacturer's bill boards, if allowed, must be submitted for the Engineer's approval.

1.20 Loading in Excess of Design Load

1.20.1 No loading in excess of the design loading shall be placed on any portion of the structure without the written permission of the Engineer

1.20.2 If such permission is granted, all beams or other members of the structure which are subjected to loading other than the designed loading shall be strengthened and supported to the satisfaction of the Engineer, and the Contractor shall be responsible for any resulting additional costs

1.20.3 The Contractor shall be responsible for making good to the satisfaction of the Engineer any damage to the permanent structure that may be caused by such excess loading.

1.21 Building Permit

1.21.1 The Contractor shall allow for obtaining the building permit and for paying all fees in connection therewith.

1.22 Permanent Drainage, Electricity and Water connection

1.22.1 The Contractor shall allow for arranging and obtaining the permanent drainage, water and electricity connections to the proposed development and he shall be responsible for making all payments in connection therewith.

1.22.2 The Contractor shall be responsible for all cutting and patching and making good required for all trades for all work and his prices will be deemed to include for all such cutting and patching and making good.

1.22.3 The Contractor shall provide a site hoarding at the boundary of the Site as required by the Municipality By-laws and to the entire satisfaction of the Municipality and the Engineer. The Site hoarding shall be maintained during the progress of the Works and shall be dismantled and cleared away upon completion.

1.22.4 The Contractor shall be responsible for ensuring the security of the Site, for protecting same from trespass and providing all necessary watching and lighting in connection therewith.

- 1.22.5 The Contractor shall follow up and obtain all the required information relating to any existing site services, telephone, electrical, water, drainage and the like on the site before commencing excavation or piling. The Contractor shall be responsible for the protection of all existing services within the site and shall make good at his expense any damage to existing services resulting from his carrying out of the Works to the satisfaction of the Engineer and relevant authority. The Contractor shall be responsible for giving notice to the relevant authority where temporary or permanent re-routing or diverting of existing services is found to be necessary and shall complete same at his own expense to the Engineer's and respective Authorities' approval.
- 1.22.6 Where diversions of services as aforementioned are not required in connection with the permanent Works, the Contractor shall uphold, maintain and keep same in working order in existing locations.
- 1.22.7 The Contractor shall satisfy himself as to the scope of the Work shown on the drawings and described in these Contract Documents and his price shall be deemed to cover all his obligations under the Contract and all matters and things necessary for the proper construction, completion and maintenance of the Works. The price shall include for all material, labour and plant - whether mechanical or non-mechanical - required for the completion of the Contract in accordance with the Drawings and Specifications, and removing at completion and making good any surfaces disturbed and if not included in any prices inserted in the Preliminaries for the insurances and bonds required; for the costs of preparing a tender; for the work in connection with measurements and the final account; for profit; and for all other establishment charges and on costs of whatever nature. No claim for additional payment will be allowed for any error or misunderstanding by the Contractor in these respects.
- 1.22.8 The Contractor has to allow in his pricing for all fees required to obtain the building permit.
- 1.22.9 Any defective work materials and also deviations from the working details in respect of setting out, correct lines and levels, verticality, sizes, thicknesses of members and/or any other dimensional variation of any kind whatsoever, shall be removed and reconstructed or otherwise rectified without undue delay to the approval of the Engineer and the Contractor shall be responsible for all additional costs incurred.

1.23 Handing Over

- 1.23.1 Prior to handing over the proposed development the Contractor shall gain the approvals and respective Completion Certificates from all the local government authorities and the like that the work has been completed in accordance with their requirements. Any payment in connection therewith shall be paid by the Contractor.

2. SITE WORKS

2.1 Demolition

- 2.1.1 Demolition includes the complete demolition including grubbing up of foundations and the proper termination of all services as required by the Drawings including the removal and disposal of all demolished materials. The demolition work shall be executed in a systematic manner.
- 2.1.2 Demolition operations and the removal of debris shall be carried out to ensure minimum interference with roads, streets, foot paths and other adjacent occupied or used facilities.
- 2.1.3 Damage caused to adjacent facilities by demolition operations shall be repaired by the Contractor at his own expense. The Contractor shall arrange and pay for the disconnecting, removing and capping of utility services, notify the affected utility agency in advance and obtain written approval before commencing work.
- 2.1.4 Before commencement of work, submit a method statement to the Engineer as to the proposed method and sequence of demolition of the building and a safety plan which shall cover the risk assessment and safety measures for such method statement. The Engineer reserves the right to prohibit any method of execution of the Works which he regards as unsafe.
- 2.1.5 Drawing information, particularly for unconventional layouts and special structures, will be made available to the Contractor if possible. The Contractor shall state in his method statement if it is based on such drawings. In the absence of drawings, the Engineer may require a detailed structural survey to be carried out and endorsed by a Registered Structural Engineer (or equivalent) to define the existing structure and the appropriate method and sequence of demolition.
- 2.1.6 No work on site shall be allowed to commence until the proposed method statement has been accepted and all precautionary measures, hoardings, covered walkways, and other requirements are in place.

2.2 Site Clearance

The Site shall be cleared of all vegetation, rock, boulders, etc. and surface soil shall be removed as directed by the Engineer. The trees which are to be retained shall be protected from damage. The roots of trees shall be removed completely.

Spreading, levelling and consolidating on site where required, shall be made with suitable surplus excavated material obtained from the Site. Other soils used for filling shall be approved by the Engineer.

The Contractor shall dispose all unsuitable and surplus excavated material.

The Contractor shall tidy up and leave the Site in a clean and sanitary condition at all times during the execution of the Works.

7.3 Excavation

- 7.3.1 Note: The contractor shall visit the site, inspect the trial holes or bores where available, and decide for himself the nature of the ground, subsoil to be excavated and the ground water levels. The furnishing of particulars of trial holes or bores for the information of the contractor does not absolve the contractor from his responsibilities nor does it guarantee that similar conditions apply on other parts of the site.
- 7.3.2 Excavation shall be performed to the required depth as shown in the Drawings.
- 7.3.3 A survey of the existing site shall be made and the results of same to be submitted to the Engineer before commencement of the work
- 7.3.4 Excavation area shall be protected from any water flowing in. Sides of excavations shall be shored or inclined to retain excavation unless otherwise specified
- 7.3.5 Excavation near adjoining structures shall be executed with care so as not to damage those structures.
- 7.3.6 The Contractor shall take all necessary precautions during the excavation for the Works particularly those excavation which are adjoining existing buildings and shall protect such buildings from the damage or collapse by means of temporary or permanent shoring, strutting, sheet piling or underpinning or excavation in short lengths and/or other methods as he deems fit and also he shall properly support all foundations, trenches, walls, floors, etc. affecting the safety of the adjoining existing buildings.
- 7.3.7 The Contractor shall alter, adopt and maintain all such works described above for the whole period of the Contract and shall finally clear away and make good all damages done.
- 7.3.8 The construction and efficiency of the shoring, underpinning, strutting and the like for the purpose for which it is erected shall be the responsibility of the Contractor, should any subsidence or any other damage occur due to the in efficiency of the shoring, underpinning, strutting and the like or any other support provided, the damage shall be made good by the Contractor at his own expense and responsibility. If any slip occurs, the contractor shall remove all the slipped material from the excavated pit without payment. If any damage to a built-up structure occurs because of the slip the contractor shall make good without any payment.

- 7.3.9 The methods of shoring/temporary earth support systems including design calculations, shall in every case, be subjected to the approval of the Engineer.
- 7.3.10 The shoring, strutting, piling and the like, shall be executed in such a manner as to cause as little inconvenience as possible to adjoining owners or the public and the Contractor shall be responsible for negotiating with the adjoining owners the means to safeguard their property and for the use of any portion of their land for the purpose of executing the excavations and no claims submitted on this ground will be entertained.
- 7.3.11 The Contractor shall be held solely responsible for the safety of the adjoining existing buildings, the sufficiency of all temporary or permanent shoring, underpinning, piling, and the like.
- 7.3.12 The Contractor shall keep the Engineer informed as to manner in which he intends to proceed with the execution of the excavations and obtain his approval. Such approval if given shall not absolve the Contractor of his responsibility.
- 7.3.13 Excavation shall extend a sufficient distance from walls, footings, etc. to allow space for placing and removing shoring and formwork, for performing all work in the excavations and for the inspection of same.
- 7.3.14 Excavated material shall be deposited within specified areas as directed unless otherwise specified.
- 7.3.15 The Contractor is deemed to have inspected the site and to leave as curtailed for himself as to the nature of the soil, etc. and also the areas where to collect and stack the materials for which necessary site clearance shall have to be made at his own cost.
- 7.3.16 Stacking or excavated materials shall be done at places approved by the Engineer and he shall have recorded the original ground levels of such places jointly with the Contractor before commencement of stacking operation.
- 7.3.17 Extra excavation and allied lead/lift required specifically for providing working space to workmen or shuttering to walls of basement etc. shall be measured for payment, no extra claim being allowed for such work incidental to development and executions of allied jobs. Only authorized excavation approved by the Engineer shall be paid for
- 7.3.18 Sufficient clear working space shall be left all around excavated area. The disposal of waste/unserviceable materials may be in filling and/or in embankment according to nature of place of disposal. The appropriate specifications for filling and/or embankment shall apply
- 7.3.19 All foundation trenches shall be excavated to the full widths and depths shown on the drawings or to such greater or smaller depths as may be found necessary in the opinion of the Engineer and so instructed by his representative.
- 7.3.20 Should any excavation be taken down below the specified levels, the

Contractor shall fill in such excavation at his own cost with cement concrete specified for foundations, well rammed in position until it is brought up to the level.

- 7.3.21 The Contractor shall notify to the Engineer when the excavation is completed and no concrete or masonry shall be laid until the Engineer has inspected of the soil for each individual footing.
- 7.3.22 All foundation pits shall be refilled to the original surface of the ground with approved materials, which shall be well consolidated as instructed by the Engineer.
- 7.3.23 The Contractor shall erect temporary barricades around the excavations and if necessary make provisions of red lamps.
- 7.3.24 The Contractor shall remove/ maintain/ restore all service lines like telephone, water supply, electricity etc. without any extra charges.

7.4 De-watering

- 7.4.1 Where the excavation level is below the natural water table and it is necessary to pump continuously from the excavation or to install a specialist type of de-watering equipment around the perimeter of the site or excavation, the Contractor will be responsible for ensuring the safety and stability of all adjoining structures and services or utilities above or below ground level.
- 7.4.2 It will also be the responsibility of the Contractor that the equipment installed shall ensure that the excavation and subsequent construction is carried out in dry conditions. The contractor shall provide, maintain and operate sufficient pumping equipment of the required capacity to keep the area of construction free of water from rain, drains, floods springs etc. during the construction period at no extra cost to the Employer.
- 7.4.3 Continuous or permanent de-watering of the excavation or Site may not be undertaken without the written approval of the Engineer and the methods to be employed shall also comply with Codes of Practice and Local Authority requirements. The contractor shall obtain the written permission of the Engineer for the method he would use to keep the excavations free from water, the procedure adopted shall not result in the withdrawal of water/soil from underneath the foundation of adjacent sites. The dewatering procedure adopted shall not result in withdrawal of water/soil from underneath the foundation if adjacent sites.
- 7.4.4 The water pumped from the excavations or well points shall be pumped to disposal points or sumps approved by the Engineer and the Local Ward Office and if so required be passed through settling tanks before disposal.
- 7.4.5 Unless prior approval has been obtained no water must be disposed of in the Municipality's sewer systems.

7.5 Back fill

- 7.5.1 No filling shall be carried out until the concrete foundations, brick footings, etc., have been inspected and approved by the Engineer. In the case of retaining walls designed as propped cantilevers, or any other structures requiring the construction of additional structural elements before filling, no filling shall be done until those specific elements have been completed and approved by the Engineer.
- 7.5.2 All earth used for filling shall unless otherwise stated, be selected hard dry material from the excavation. The maximum dry density of the fill material shall be not less than 1600 kg/m^3 . The excavated suitable hard dry material arising from all excavations declared by the Engineer's Representative to be suitable for fill is to be used as filling. All other filling material shall contain no perishable or organic rubbish and no particles in excess of 150mm in diameter.
- 7.5.3 The backfill of excavations shall be placed in horizontal layers not exceeding 150mm in thickness. Each layer shall be watered and compacted by mechanical means to the required density before the next layer is added. (to the satisfaction of Engineer) the filling shall be continued at least 75mm above the final level.
- 7.5.4 Care shall be taken when filling or back-filling to avoid any wedging action or eccentric action upon or against the structure of the work.
- 7.5.5 Before placing of fill, the surface of the sub-grade shall be compacted at optimum water content to the same percentage of maximum dry density required of subsequent lay.
- 7.5.6 Filling and backfilling shall be placed in layers not exceeding 150mm thick (after compaction). Each layer shall be uniformly spread and shall be moistened or dried by aeration when required to ensure the optimum water content and shall be compacted uniformly by hand or machine methods of specified density as follows:-

Filling under footings, water tanks, concrete beds, sidewalks and other bearing situations	At least 98% maximum dry density
Fill within 300mm, measure horizontally, of foundation walls, retaining walls, edges of footings, and other below grade vertical surface. When machine compacted, compaction shall be by means of a 6 ton smooth wheeled roller.	AT least 95% maximum dry density

- 7.5.7 The Engineer's Representative shall have the right to disapprove any compacting device of inadequate capacity or in his opinion, of type unsuited to the character of the material being compacted. Heavy equipment for

spreading and compacting fill and backfill shall not be operated closer to walls than a distance to the difference in height between the top of the footings and the layer being compacted

7.5.8 Testing to determine the density of in place soil shall be by means of ASSHTO Standard Method of Test T147 or in accordance with BS 1377: 1975. The number of density tests per layer shall be as instructed by the Engineer's Representative.

7.5.9 No backfilling shall be carried out until the wall concrete has achieved its full works cube strength and care shall be exercised so as not to damage the external tanking membrane and its protection.

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

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

7.5.11 Trenches shall not be backfilled until all required pressure tests have been performed and until the utility systems, as installed, conform to the requirements of the Specifications governing mechanical, electrical, and utility work.

7.5.12 Where, in the opinion of the Engineer's Representative, damage is likely to result from withdrawing sheeting, the sheeting shall be left in place. The trenches shall be carefully backfilled with approved backfilling materials, as hereinbefore specified, deposited in 150mm layers and thoroughly and carefully hand tamped until the pipe has a cover of not less than 300mm for electric ducts, and 600mm for sewers and water mains. Where the pipe is specially coated for protection against corrosion, care shall be taken not to damage the coating. The remainder of the backfill material shall then be placed in 150mm layers, and compacted by hand hammers or mechanical tampers to at least 90% maximum dry density. Settling the backfill with water will be permitted, and will be a requirement, when so directed by the Engineer's Representative. Any trenches improperly backfilled, or where settlement occurs, shall be reopened to the depth required for compaction, then refilled and compacted, with surface restored to the required grade and compaction, mounded over and smoothed off.

7.5.13 Trenches under buildings, open trenches across parking areas and trenches at other areas to be paved shall be backfilled as specified above, except that the entire depth of the trench shall be backfilled in 150mm layers and each layer

shall be moistened and compacted to at least 98% of maximum dry density, to provide the required bearing value, so that construction or paving over the area can proceed immediately after backfilling is completed. Along all other portions of the trenches, the ground shall be graded to a reasonable uniformity and the mounding over of the trenches left in a uniform and neat condition to the satisfaction of the Engineer's Representative.

7.5.14 The Engineer will inspect all compacting devices that the Contractor proposes and shall have the right to reject any device which he feels is unsuitable for the job.

7.5.15 Heavy equipment for spreading and compacting fill and backfill shall not be operated closer to walls than a distance to the difference in height between the top of the footings and the layer being compacted.

7.5.16 When back-filling behind retaining walls, basement walls and the like the said structures shall be kept propped during the complete operation. The hydraulic compaction of fill shall not be permitted and the back filling shall be carried out in layers not exceeding 150mm thick.

7.6 Nature of Soil

7.6.1 The Contractor is to visit the Site and ascertain for himself the condition of the surface of the ground and the type of substrata likely to be encountered in the excavation of the proposed development.

7.7 Finish of Excavation and Inspection

7.7.1 The Engineer's Representative shall inspect all the excavations before commencement of further work and the Contractor shall notify the Engineer's Representative when excavations are ready for inspection.

7.7.2 The Engineer's Representative may instruct the Contractor to test the bearing capacity of the soil in the bottom of excavations. Upon receipt of such instructions, the Contractor shall forthwith carry out such tests as the Engineer's Representative may instruct at the Contractor's expense.

7.7.3 Should the bottoms of excavation be found to be unsuitable as bearing surfaces as a result of such tests or inspection by the Engineer's Representative, the Contractor shall excavate further as directed until a satisfactory bearing surface is achieved.

7.7.4 No excavation shall be refilled nor any permanent work commenced until the formation has been inspected by the Engineer's Representative and his permission to proceed given. If required by the Engineer's Representative the bottom 150mm of excavation shall not be removed until just before the commencement of construction of permanent work.

7.8 Removal of Water

7.8.1 The excavations shall at all times be kept free from storm water, percolating

water or subsoil water by any means necessary. The Contractor shall provide, maintain and clear away on completion any equipment necessary together with temporary drains and the like. Under no circumstances shall concrete be poured, fill placed, pipes laid or appurtenances installed in excavations containing water.

7.9 Sheeting and Shoring

- 7.9.1 Sheeting and shoring shall be provided at excavations to ensure complete safety against collapse of soil at sides of excavations, to provide protection of workmen and to prevent damage to adjacent property, structures, paving and utilities.

7.10 Storage and Disposal of Excavated Material

- 7.10.1 Excavated material shall not be piled along sides of excavations in a manner that will overload or increase danger of collapse of excavation sides. All excavated material shall be neatly piled in stock piles but where this is not practicable the excavated material shall be removed from site.
- 7.10.2 Excavated material shall be separated into those suitable for fill and those unsuitable for fill as directed by the Engineer's Representative. Materials unsuitable for fill shall, as soon as practicable, be removed from site.
- 7.10.3 Material suitable for fill shall be put to immediate use or stockpiled at the option of the Contractor. Under no circumstances shall material declared to be suitable for fill be stored next to materials declared to be unsuitable for fill. Stockpiles of materials suitable for fill shall be located in areas as approved by the Engineer's Representative in the vicinity of the work, located so as not to interfere with the progress of the works. Stockpiles shall be kept in a neat, well drained workable condition at all times.

7.11 Disposition of Existing Utilities

- 7.11.1 Before commencing any construction work, the Contractor shall obtain from the various utilities Departments, Companies or Employer the location of any existing utilities on the Site. Active utilities on the Site shall be carefully protected from damage, relocated or removed as required by the work. When an active utility line is exposed during construction, its location and elevation shall be plotted on the Record Drawings and both the Engineer's Representative and the utility owner notified in writing.
- 7.11.2 Inactive or abandoned utilities encountered during construction operations shall be removed, plugged or capped. The location of such utility shall be noted on the Record Drawings and reported in writing to the Engineer's Representative.
- 7.11.3 Active utility lines damaged during the course of construction operations shall be repaired or replaced as determined by the Engineer's Representative at the Contractor's expense. Immediately an active utility line is damaged the Contractor shall notify the Engineer's Representative and the utility owners by telephone and in writing.

7.12 Safety of Adjoining Existing Buildings

- 7.12.1 The contractor shall carry out a pre-crack survey before the commencement of construction, and a post-crack survey after the completion of construction, of the adjacent buildings at their own cost, to ensure that no damage has occurred during the construction.
- 7.12.2 The Contractor shall take all necessary precautions during the excavation for the Works particularly those excavation which are adjoining existing buildings and shall protect such buildings from the damage or collapse by means of temporary or permanent shoring, strutting, sheet piling or underpinning or excavation in short lengths and/or other methods as he deems fit also he shall properly support all foundations, trenches, walls, floors, etc. affecting the safety of the adjoining existing buildings.
- 7.12.3 The Contractor shall alter, adopt and maintain all such works described above for the whole period of the Contract and shall finally clear away and make good all damages done.
- 7.12.4 The construction and efficiency of the shoring, underpinning, strutting and the like for the purpose for which it is erected shall be the responsibility of the Contractor, should any subsidence or any other damage occur due to the inefficiency of the shoring, underpinning, strutting and the like or any other support provided, the damage shall be made good by the Contractor at his own expense and responsibility.
- 7.12.5 The shoring, strutting, piling and the like, shall be executed in such a manner as to cause as little inconvenience as possible to adjoining owners or the public and the Contractor shall be responsible for negotiating with the adjoining owners the means to safeguard their property and for the use of any portion of their land for the purpose of executing the excavations and no claims submitted on this ground will be entertained.
- 7.12.6 The Contractor shall be held solely responsible for the safety of the adjoining existing buildings, the sufficiency of all temporary or permanent shoring, underpinning, piling, and the like. The Contractor shall keep the Engineer informed as to manner in which he intends to proceed with the execution of the excavations and obtain his approval; such approval if given shall not absolve the Contractor of his responsibility under this Clause.
- 7.12.7 The Contractor shall save harmless and indemnify the Employer in respect of all claims, demands, proceedings, damages, costs, charges and expenses whatsoever arising out of or in relation to any such matters in so far as the Contractor is responsible under this Clause.

3. CONCRETE WORKS

3.1 General

- 3.1.1 Materials used in the Works shall be new, of the qualities and kinds specified herein and equal to approved samples. Delivery shall be made sufficiently in advance to enable further samples to be taken and tested if required. No materials shall be used until approved and materials not approved shall be immediately removed from the Works.
- 3.1.2 Materials shall be transported, handled and stored on the site or elsewhere in such a manner to prevent damage, deterioration or contamination.

3.2 Cement

- 3.2.1 Cement shall, unless otherwise stated, be Portland cement of an approved brand and shall comply with the requirements and shall satisfy the tests contained in British Standard No.12 or ASTM C-150 for cement Type 1.
- 3.2.2 Cement shall be of recent manufacture and shall be used within a period of 3 months of manufacture.
- 3.2.3 The Contractor shall with each fresh consignment of cement delivered to the site furnish the Engineer with a copy of the Manufacturer's statement of compliance with the above Standard Specifications together with the date of manufacture, certified by an independent agency in the country of origin and its date of delivery to Site.
- 3.2.4 Check tests will be required by the Engineer. These tests shall be carried out at the Contractor's expense. Any cement failing to meet the required standards will be rejected and replaced at the Contractor's expense.
- 3.2.5 The initial setting time shall not be less than 45 minutes and the final setting time not more than 10 hours for Ordinary Portland Cement.
- 3.2.6 The Engineer may extract samples of consignments of cement as and when he desires for the purpose of testing. Testing shall conform to the relevant British standards. If the sample fails the test, the particular consignment shall be rejected and shall be removed from the site within 24 hours of notice in writing to the contractor to do so. Any consignment of cement stored at site

for more than 3 months shall be re-tested if so, required by the Engineer.

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

3.3 Normal Weight Aggregate

- 3.3.1 Fine aggregate for use in the production of concrete shall be of river sand and shall conform to the requirements of BS 882. Its grading shall be to Zones 1, 2 or 3 as defined in BS 882 and shall have not more than 10% retained on the 5 mm sieve.
- 3.3.2 Course aggregate for use in the production of concrete shall be composed of crushed gravel or stone. It shall conform to the requirements of BS 812 and shall have not more than 10% passing the 5 mm sieve.
- 3.3.3 Sources of aggregate shall be to the approval of the Engineer and samples of aggregate from the proposed sources shall be submitted to the Engineer at least 28 days before intended use. No new sources of aggregate will be permitted without prior approval of the Engineer.
- 3.3.4 Aggregates shall be sampled and tested in accordance with the appropriate Standards. They shall be free from salt and other organic impurities and shall contain not more than 0.03% by weight of chlorides nor 0.4 % by weight of sulphates.
- 3.3.5 Any aggregates which fail to meet these requirements shall be rejected and removed from the site, following which the Contractor's sources of supply shall be re-examined for suitability.

3.4 Water

- 3.4.1 Fresh water or MWSC water containing not more than 10 parts per million dissolved solids shall be used for all reinforced concrete work. It shall not contain vegetable matter, acid, sulphates, chlorides or other salts in such quantities as to cause efflorescence on the face of the concrete nor to effect adversely the setting time or strength of the concrete nor to instigate electrochemical corrosion of the reinforcement.

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

- (a) Suspended matter- 2,000 mg/litre

(b) Dissolved matter (max concentration)

Sodium & Potassium Bicarbonate 1.000 mg/litre
Sodium Chloride 20,000 mg/litre
Sodium Sulphate 10,000 mg/litre
Ca +Mg Bicarbonate as HCO₃ 400 mg/litre
Calcium Chloride 20,000 mg/litre
Iron Salts-40,000 mg/litre
Sodium Iodate. Phosphate, Arsonate & Borate 500 mg/litre
HCl + H₂SO₄-10,000 mg/litre
NaOH-5,000 mg/litre

(c) pH value of water shall generally be not less than 6.

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

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

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

3.5 Storage

3.5.1 Storage accommodation for materials for use in concrete shall be subject to the approval of the Engineer and shall afford easy access for inspection and identification of each shipment in accordance with test reports.

3.5.2 Cement

3.5.2.1 The cement shall be delivered to site in the original sealed bags or containers from the manufacturer and shall be stored in a dry, weather-tight, properly ventilated structure, with adequate provisions for preventing the absorption of moisture and raised at least 15cm off the ground to prevent deterioration.

3.5.3 Aggregate

3.5.3.1 Shall be stockpiled in separate gradings and protected against the inclusion of windblown dust, sulphates and other foreign matter.

3.5.3.2 When aggregates of different gradings are stockpiled close together the stockpiles shall be separated by bulkheads. The stockpiles are to be on concrete or other hard surface sufficiently sloped so that water is not retained in the base of the stockpiles. All aggregates are to be handled from the stockpiles in such a way as to secure a typical grading of the material, care being taken to avoid crushing the aggregates and

contamination with extraneous matter. Aggregates with low absorption shall be used for the all concrete that is exposed to the weather or contact with liquid.

3.5.4 Sand

3.5.4.1 Sand shall be stored under cover and sheltered from windblown dust, sulphates and foreign matter.

3.6 Mix Proportion

3.6.1 The Contractor, having knowledge of the source and type of cement, aggregates, plant and method of placing he intends to use for the aggregate/cement ratios and water/cement ratios which he considers will achieve the strength requirements specified and will produce a workability which will enable the concrete to be properly compacted to its full depth and finished to the dimensions and within the tolerances shown on the Drawings, shall be responsible for designing his concrete mixes within the following limitations. The aggregate/cement ratios and the water/cement ratio shall not exceed the upper limits specified below. Furthermore, the quantity of cement per cubic meter of concrete shall in no case be less than the minimum specified: -

Normal weight concrete grades	Characteristic compressive strength of cubes at 7/28 days		Maximum aggregate size (mm)	Maximum free water cement ratio	Kg of cement per cubic metre of compacted concrete	
	7 days	28 days			Max	Min
30 for on land structures and 40 for on water structures	21	30	20	0.42	450	350
	28	40	20	0.42	450	350

3.6.2 As soon as possible after commencement of the Contract, the Contractor shall submit mix designs for the approval of the Engineer and upon the approval prepare trial mixes as required to satisfy the Engineer that the specified concrete strengths will be obtained using the materials and mix proportions in accordance with the above clauses. The proportion of cement shall be increased if necessary to obtain the strengths required.

3.6.3 From each trial mix, six Preliminary Test Cubes shall be made and tested two at 7 days and four at 28 days, the test at 7 days being intended to give an early indication of possible variation from the required strength. If the difference between the highest and lowest results from any one trial mix is more than 15 per cent of the average of the strength test results, the test is to be discarded and a further trial mix made, unless all test results so obtained

are above the required strength.

3.6.4 In TRIAL MIX the average compressive strength of the three cubes tested at 28 days shall exceed the specified characteristic strength by at least 10 N/sqmm

3.6.5 All the material properties, proportions and methods are complied with the relevant British Standards.

3.7 Batching and mixing of concrete

3.7.1 Concrete may be batched either by weight or by volume. It may be batched and mixed on Site or outside the Site and transported thereto.

3.7.2 When mixed outside the Site and transported to it, batching and mixing shall be in accordance with ASTM Specification C94 "Standard Specification for Ready Mixed Concrete".

3.7.3 When mixed on Site, batching and mixing shall be as follows;

3.7.4 Batching by Weight:

3.7.4.1 The cement and each size of aggregate shall be measured by weight. The water may be measured by weight or volume. The weight batching machines used shall be of an approved type, and shall be kept in good condition while in use on the Works. Checks are to be made as required to determine that the weighing device are registering correctly.

3.7.5 Batching Aggregate by Volume:

3.7.5.1 When batching aggregates by volume is allowed, the cement shall be batched by weight and the aggregate and water by weight or volume. Each size of aggregate shall be measured in metallic containers the depth of which is at least equal to their greatest width. The containers shall be of such shape that their volume can be easily checked by measurement.

3.7.6 Mixing Concrete:

3.7.6.1 The location of the batching and mixing plant shall be approved by the Engineer.

3.7.7 Concrete shall be mixed in a batch mixer of an approved type and in good condition having a drum rotation about a horizontal or inclined axis. A continuous mixer shall not be used. Each mixer is to be fitted with a water measuring device having an accuracy within one percent (1%) of the quantity of water required for the batch.

3.7.8 The water measuring device shall be such that its accuracy is not affected by

variations in the water supply pressure.

- 3.7.9 The batch shall be so charged into the mixer that some water (about 10%) enters the drum in advance of the cement and aggregates, water shall then be added gradually while the drum is in motion such that all required water shall be in the drum by the end of the first quarter of the mixing time. The concrete shall be mixed until a mixture of uniform colour and consistency is obtained.
- 3.7.10 The amount of concrete mixed in any one batch is not to exceed the rated capacity of the mixer. The whole of the batch is to be removed before materials for a fresh batch enter the drum.
- 3.7.11 On cessation of work, including all stoppages exceeding 20 minutes, the mixers and all handling plant shall be washed with clean mixing water. If old concrete deposits remain in the mixer drum, it shall be rotated with clean aggregate and water to clean out the drum prior to production of new concrete. The material shall be mixed for a period of not less than 2 minutes until uniform color and consistency are obtained. The time shall be counted from the moment all the materials have been put into the drum.
- 3.7.12 Concrete mixed as above is not to be modified by the addition of water or in any other manner to facilitate handling or for any other reason.

3.8 Placing

- 3.8.1 Concrete shall be conveyed from the mixer to its final position in any suitable manner, provided there is no segregation, loss of ingredients or contamination. It shall be placed in its final position before initial setting takes place and within 20 minutes of the addition of the water to the mixer. However, when agitating equipment is used to convey concrete such as in ready-mixed concrete, the elapsed time between the addition of the water and placing may be increased to 45 minutes unless retarder is used.
- 3.8.2 The order of placing concrete shall be such as to prevent water from collecting at the ends, corners and along the faces of forms. It shall not be placed in large quantities at any given point and allowed to run or be worked over a long distance in the form. Whenever possible concrete shall be placed and compacted in even layers with each batch adjoining the previous one.
- 3.8.3 The thickness of each layers shall be between 15 and 30 cms as agreed with the Engineer. The layer thickness will depend on the width of forms, the amount of reinforcement and the need to place each layer before the previous one stiffens.
- 3.8.4 Concrete shall not be allowed to drop freely for more than 1.50 m. To convey the concrete as near as possible to its final positions, drop chutes of rubber or metal shall be used for small sections and bottom dump buckets or other suitable vessels for large sections.

- 3.8.5 Concrete shall be carefully compacted when placed to ensure a dense and uniform mass free from air holes and cavities. Concrete shall be compacted by vibrations. Vibration shall be performed by mechanical or electromechanical vibrators. The vibrators shall be of the plunger (poker) type for insertion in the concrete.
- 3.8.6 The poker type vibrators shall have a diameter compatible with spacing of reinforcement, a sufficiently high frequency and be properly handled by experienced personnel. They shall be immersed at regular intervals close enough to vibrate all the concrete, but not so close as to affect previously vibrated and partially set concrete. Each immersion shall continue until shortly after air bubbles cease to appear on the surface of the concrete, but shall not last more than 30 seconds. The vibrators shall be withdrawn gradually to ensure that no air pockets are formed.
- 3.8.7 All vibrations, compaction and finishing operations shall be completed within 15 minutes from the time of placing the concrete in its final position.
- 3.8.8 Concreting for any one part or section of the work shall be carried out in one continuous operation, and no interruption of concreting work will be allowed. Where beams and slabs together form an integral part of the structure, they shall be poured in one operation, unless provision is made to form a construction joint. A record is to be kept by the Contractor on Site of the time and date of placing the concrete in each portion of the works and the number and identification of the Works Tests Cube corresponding to these portions.

3.9 Testing

Sampling and Compliance Criteria For Strength of Concrete.

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

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

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

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

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

less than 1 sample per day per grade.

Testing Plan and Compliance Criteria

Two test specimens from a sample shall form a single result. The specimens shall be cured as follows:

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

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

Compliance with the characteristic strength is based on groups of four consecutive test results. Compliance with the specified characteristic strength may be assumed if the average strength determined from any group of four consecutive test results and if each individual test result complies with the appropriate limits in columns A and B of Table 5.6 respectively.

When there are less than four results, i.e. at the start of a job or on small jobs, the average of the first 2 or first 3 results, and the individual results should comply with the appropriate limits in columns A and B of Table 5.6 respectively.

For a test result to be valid, the difference between the strengths of two specimens prepared from the same sample shall not exceed 15% of the mean strength.

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

Note 1:

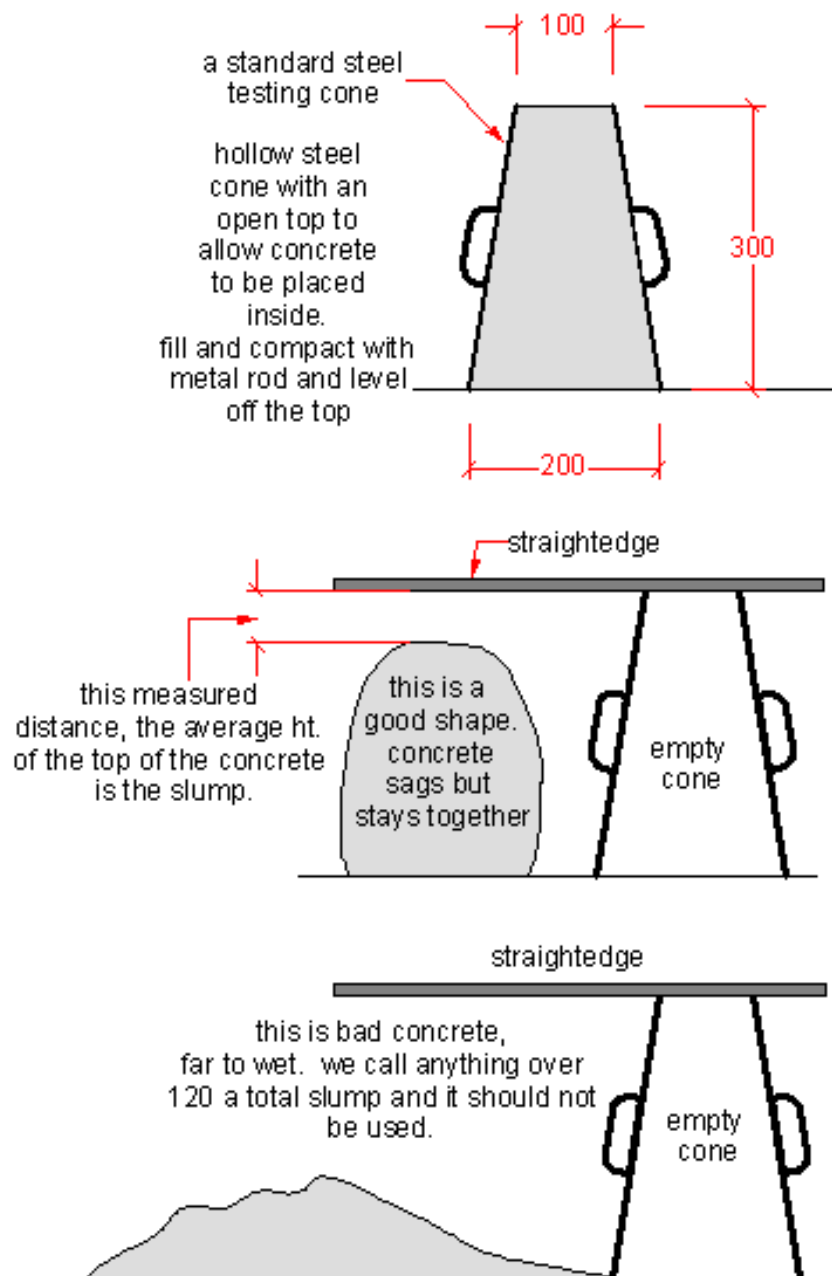
If the work is of minor nature or when the total volume of concrete is small, the following alternative scheme may be used, i.e.

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

Note 2 :

The quantity of concrete represented by a group of 4 consecutive test results shall include the batches from which the first and last samples were taken together with all intervening batches. Similarly the first 2 or 3 results shall be taken as representing all the intervening batches. For the individual test results requirements given in column B of Table 5.6 only the particular batch from which the sample was taken shall be at risk.

3.9.1 Slump Test



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

Bottom diameter - 200 mm

Top diameter - 100 mm

Height - 300 mm

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

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

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

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

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

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

3.10 Curing

- 3.10.1 Freshly placed concrete shall be protected from rain, dust, chemical attack and the harmful effects of heat, wind, flowing water, vibrations and shocks. This protection shall continue until the concrete is sufficiently set such that it can no longer be damaged by these factors which shall not be less than 24 hours after the time of placing.
- 3.10.2 Concrete shall be cured for at least 7 days or longer if instructed.
- 3.10.3 Timber formwork covering the concrete shall be moistened with water at frequent intervals to keep it from drying during the curing period. Metal formwork exposed to the sun must be shaded from its direct rays, painted white or otherwise protected during the curing period. Not recommended to use curing agents without the approval of structural engineer and recommended testing.

3.11 Formwork

- 3.11.1 The Contractor shall supply, design, erect, strike and remove the formwork and be entirely responsible for its stability and safety so that it will carry the wet concrete and all incidental loadings and preserve it from damage and distortion during its placing, vibration, ramming, setting and curing. It shall be so constructed as to leave the finished concrete to the dimensions shown on the Drawings and of a material capable of providing the surface finish specified. In any event, the maximum permissible deflection under all load shall not exceed 2mm or 1/600 of the free span, whichever is less.
- 3.11.2 Formwork shall be constructed so as to prevent the loss of any liquid from the wet concrete and to be removable without shock to the partially set concrete. When the concrete is to be vibrated, all wedges must be nailed so as to prevent slipping or distortion.
- 3.11.3 Formwork shall be of timber and/ or metal and shall include all temporary concrete moulds and their supports.
- 3.11.4 For concrete surfaces which are to be plastered, clean sawn boards should be used.
- 3.11.5 For concrete surfaces which are to remain exposed wrought formwork shall be of timber framing lined with 12mm thick smooth polyurethane faced plywood or an equal approved lining or of metal, suitable to obtain a fair-faced finish on the concrete. Where columns or beams are shown as chamfered wrought hardwood fillet shall be planted in the angles of the formwork. Except where shown otherwise on the drawings, all exposed concrete corners and arises shall have a 15 x 15mm chamfer.
- 3.11.6 All formwork is to be thoroughly cleaned of any concrete or any other deposits. Immediately before concreting, formwork shall be thoroughly

hosed down with water, temporary openings being provided to permit the escape of sawdust, shavings etc., with the water.

3.11.7 Wherever required and prior to placing of the reinforcement the internal surfaces of all formwork shall be treated with an approved mould oil.

3.11.8 Unless otherwise specified, the minimum period before striking formwork shall be as follows.

Columns	2 days
Beams, sides	2 days
Beams, soffits	21 days
Beam props	21 days
Suspended slabs, soffits	21 days
Slab props	21 days

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

3.11.9 Any work showing signs of damage through premature loading is to be entirely reconstructed at the Contractor's expense.

3.11.10 The Contractor is entirely responsibility for the safe removal of formwork and all other temporary works.

3.11.11 Props used for centering shall be of steel, timber post round poles or any other material approved by Engineer. Bamboo props or supports shall be permitted for heights or lengths not exceeding 3 metres provided they are adequately braced. In no case shall round poles be of diameter less than 100 mm measured at mid length and 80 mm at thin end. Maximum permissible spacing shall be 1.2 metres centre to centre. Poles shall rest squarely on wooden sole plates of 40 mm thickness and a minimum bearing area of 0.1 sq. metre laid on the ground. Double wedges shall be provided between the sole plates and the wooden props so as to facilitate tightening and easing of

shutting without jarring the concrete.

The details of propping and centering stated above shall be applicable for spans of 4.5 metres and height up to 3.5 metres. In case any of these limits is exceeded the formwork shall be properly designed. In case the height of centering exceeds 3.5 metres, the props shall be provided in multistages and stabilized with suitable diagonals and rakes.

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

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

In case of balconies and cantilever beams coming one above the other, the members being cast shall be supported by props on two floors below the floor where initial supporting has been done. Poles shall rest squarely on wooden sole plates of 40 mm thickness and with minimum bearing area of 0.1 square metre

3.12 Construction Joints

- 3.12.1 Whenever placing of concrete is discontinued within a bay or prior to completing a member, a construction joint shall be formed. Construction joints are to be made only along a horizontal or vertical plane except that in the case of inclined or curved members they shall be at right angles to the principal axis. Care shall be taken to prevent off-setting of the joint and to ensure water tightness.
- 3.12.2 Unless otherwise shown on the Drawings, construction joints will not be allowed in the unsupported sections of slab, beams and beamlike members. At construction joints the laitance film and porous layer of the already set concrete shall be removed and the surface keyed by hacking and then wire brushed and thoroughly cleaned. Immediately before adding the fresh concrete, the surface is to be thoroughly wetted and a 10 mm thick coating of a fresh cement/sand mortar (having the same proportion of cement/sand as concrete in the mix) applied to the surface. The new concrete is then to be well compacted against the old.

3.13 Reinforcement

- 3.13.1 Reinforcement shall be high yield deformed bars or mild steel complying with B.S. 4449 or welded wire fabric complying with B.S. 4483, except that

the characteristic strength for mild steel reinforcement shall be 250N/mm² and for high yield steel shall be 460 N/mm².

- 3.13.2 High yield bars will be shown on drawings with T prefix. Mild steel bars will be shown on drawings with R prefix.
- 3.13.3 Reinforcing bars are to be stored clear off the ground and shall be truly straight. Suitable covering shall be provided to protect against windblown sulphates, chlorides and other deleterious matter.
- 3.13.4 Manufacturer's test certificates for all classes of reinforcement shall be supplied when required. Specimens sufficient for three tensile tests and three cold-bending tests per ten tonne of bars or fraction thereof and for each different size of bars shall be sampled. Testing shall be in accordance with B.S.4449 and batches shall be rejected if the average results for each batch is not in accordance with BS4449.
- 3.13.5 All steel is to be totally free from dirt, paint, loose rust or scale and is to be thoroughly brushed and cleaned after positioning and immediately prior to concreting.
- 3.13.6 The bars are to be accurately bent to the shapes indicated, and the bending must, wherever possible, be completed before the steel is fixed in position. Straight portions of bars must be true and bends must be kept out of winding. The internal radius of bends shall not be less than four times the diameter of the bar, except for stirrups and column binders. Great care is to be taken to bend stirrups and column binders to fit closely around the main bars. In the absence of reinforcement bending schedules the bending requirements of B.S. 4466 "Bending Dimensions of Bars for Concrete Reinforcement" or other similar approved standard shall govern.
- 3.13.7 Except where agreed by the Engineer all bars are to be bent cold.
- 3.13.8 Lengthening of bars by welding and re-bending of incorrectly bent bars will not be permitted.
- 3.13.9 Unless otherwise stated splices in reinforcing bars shall be formed by lapping. Such laps in bars in any member shall be staggered. Except as otherwise indicated on the Drawings, the minimum overlap of lapped splices shall be 40 bar diameters or 30cm, whichever is greater.
- 3.13.10 The steel is to be fixed in position exactly as indicated and the bars are to be securely wired together with 1.6 or 1.4mm soft iron wire or approved spring steel slips wherever necessary to prevent any displacement during concreting. Spacers, chairs and the like, temporary or permanent, are to be used as required to ensure that the steel has the exact amount of cover indicated. No permanent spacers may show on a surface where a fair faced concrete finish or brushed aggregate finish are required.

3.13.11 Unless otherwise indicated, the minimum cover to the reinforcing bars and to binding wire shall be as follows:

POSITION	COVER mm
Main bars in columns	40-45
Main bars in floor slabs and soffits of roof slabs	30
Main bars in top of roof slabs	30-35
Bars in top ground slabs	30-35
Bars at faces in contact with soils	50-55
Clear cover in beams	35-40

3.13.12 The Contractor is to ensure that no steel is displaced from its position during the placement of concrete.

3.13.13 All reinforcement to be sprayed with water two hours before concreting commences.

3.14 Admixtures

3.14.1 Admixtures shall be used as specified by the Engineer. Prior approval of the admixture is required if the proposed admixture is different from what is specified in the drawing. Dir. The rates and methods of application shall be strictly in accordance with the manufacturer's written instructions.

3.15 Concrete below Ground

3.15.1 All concrete faces below ground are to be protected as specified in the drawing and according to the manufacturer's written instructions or as approved by Engineer.

3.16 Tolerances

3.16.1 Except where otherwise noted on the Drawings, concrete surfaces shall be cast with the following tolerances:

Sizes of beams, thickness of walls	+/- 3mm
Setting out dimensions, horizontal or vertical	+/- 6mm
Surface slabs	+/- 5mm
Verticality of columns, walls and straightness of beam faces	+/- 2mm in 3m (but not more than +/- 5mm overall)

3.17 Watertight Construction

3.17.1 All concrete work in swimming pools, plunge pools in-situ Jacuzzis and

similar construction below the water table shall be watertight. Swimming pools located in the sea/lagoon and using sea-water do not need to meet this requirement.

- 3.17.2 The Contractor shall include in his rates for such waterproof additives as he deems to be necessary, subject to the prior approval of the Engineer, or as instructed on the drawings.
- 3.17.3 When in the opinion of the Engineer, damp patches or leakage of water in the finished work are due to failure of the Contractor to comply with the specification, the affected work shall be made good at the Contractor's expense.
- 3.17.4 Water bars shall be provided as shown on the drawings and at all construction joints and the type of water bar will be as specified or to the approval of the Engineer. All water bars shall be jointed and supported strictly in accordance with the manufacturer's instructions.

3.18 Mortar

3.18.1 Description

- 3.18.1.1 Mortar for bedding kerbs, channels, cover frames etc shall be 1:4 cement: sand mortar.
- 3.18.1.2 Mortar for grouted stone pitching shall have 5% by weight of hydrated lime added to it.
- 3.18.1.3 Mortar for use with block work and rendering shall be 1:5 cement: sand mortar, and shall have a trial strength at 28 days of min 7 N/mm², (when tested in a 100 x 100 test cube).

3.18.2 Materials

- 3.18.2.1 Cement shall be Portland cement to BS12 and sand shall be a natural sand or crushed natural stone or a combination of both as specified in BS 1200.

3.18.3 Mixing

- 3.18.3.1 Mortar shall be mixed thoroughly either by hand or mechanically until its colour and consistency are uniform. The consistent materials shall be accurately gauged, allowance being made for bulking of sand. Mortar shall be made in small quantities only as and when required. Mortar which has begun to set or which has been mixed for a period of more than one hour shall be discarded.
- 3.18.3.2 Mortar plasticisers may be used with the Engineer's approval, but in no circumstances shall calcium chloride be permitted.

4. BLOCKWORK

4.1 Materials

4.1.1 Cement:

4.1.1.1 Ordinary Portland Cement shall be used as described under concrete work. White or coloured cement shall comply with the physical requirements of B.S 12.

4.1.2 Lime:

4.1.2.1 Lime shall be hydrated lime complying with B.S 890 Class B to be soaked in water for not less than 16 hours before use.

4.1.3 Water:

4.1.3.1 Water shall be as described under Concrete Works.

4.1.4 Sand:

4.1.4.1 Sand shall be as described under Concrete Works.

4.1.5 Concrete Blocks:

4.1.5.1 Blocks shall be manufactured of cement and sand 1:5 mix (300 Kg cement to one metre cube of sand) made in vibrated pressure machines. They shall be hard, sound, square and clean with well defined arrises and shall be 400 mm (± 5 mm) long x 200mm (± 5 mm) high unless otherwise shown on the Drawings. The tolerance of thickness shall be (± 3 mm).

4.1.5.2 Unless otherwise shown on the Drawings blocks shall be hollow blocks and shall be of approved design.

4.1.5.3 Immediately after moulding, blocks shall be placed on clean, level, non-absorbent pallets. Blocks shall not be removed from the pallets until they have been inspected and approved by the Engineer. Blocks shall be steam cured for 14 days.

4.1.5.4 Blocks shall be tested for compressive strength whenever required by the Engineer. For each test twelve blocks will be selected by the Engineer. The average compressive strength for the gross area of hollow blocks shall be not less than ~~25 kg/cm²~~ 2.45N/mm² and the minimum block shall be ~~20 kg/cm²~~ (1.96N/mm²).

4.1.5.5 Should a test not meet the above requirements, the batch of

blocks from which the sample was taken, will be rejected and shall be removed from the Site.

Strength requirements

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

- (a) the average crushing strength of 10 bricks shall be not less than 7.0 N/mm²
- (b) the average crushing strength of 10 blocks shall be not less than 2.8 N/mm²
- (c) the coefficient of variation for the sample shall not exceed 20% Blocks less than 75 mm shall be tested for transverse strength in accordance with the code and the average transverse strength of 5 blocks shall be not less than 0.65N/mm²)

4.1.6 Aerated Concrete Blocks:

- 4.1.6.1 Shall conform to BS 8110 Part 2:1985 and BS 6073 Part 1:1981 for method of casting, density, thermal conductivity and strengths. Density of block shall guarantee good resistance to rain penetration as unprotected single leaf wall

4.2 Mortar

- 4.2.1 Mortar shall consist 1 part cement to 5 parts of sand by volume. For work not in contact with earth or sand, one part lime may be added to the mix. Mortar for pointing facing concrete blocks shall be prepared using white cement. When block work is constructed below ground level sulphate resisting cement shall be used.
- 4.2.2 Mixing shall be carried out by means of an approved mechanical batch mixer. The mortar shall be mixed dry until a uniform mix is obtained. Sufficient water shall then be added and the mixing continued until a homogenous mix is obtained. Excess water shall not be used in the mix.
- 4.2.3 All mortar shall be used before the initial set has taken place and on no account shall mortar which has commenced to set be remixed with water or new batches and used.

4.3 Workmanship

- 4.3.1 Generally workmanship shall be in accordance to BS 8000.
- 4.3.2 Block work shall be set out and built to the respective dimensions, thicknesses and heights shown on the Drawings and/ or as instructed in writing by the Engineer.

- 4.3.3 Unless otherwise ordered, hollow blocks shall be used In all closures, end blocks such as at door jambs, window openings, etc., and blocks of special lengths or size, shall be solid. The blocks shall be well soaked before being used and the tops of walls left off shall be wetted before work is recommenced.
- 4.3.4 Blocks shall be laid in true and regular courses on a full bed of mortar of 10 mm average thickness, exclusive of any key in the jointing surfaces of the blocks. Sufficient mortar shall be used in bedding and jointing to ensure that all keys are solidly filled. Where blocks abut against concrete each third course shall be tied thereto by means of approved galvanized steel ties.
- 4.3.5 All horizontal joints shall be properly level. The Vertical joints shall be properly lined and quoins, jambs and other angles plumbed as the work proceeds.
- 4.3.6 All walls shall be plumbed vertical.
- 4.3.7 Standard sized block shall be used wherever possible. Broken blocks shall not be used except where required for bonding purposes. Walls and partitions shall be bonded to one another at angles and junctions.
- 4.3.8 Joints of faces of block walls which are to be rendered or plastered shall be raked out for depth of 10 mm as the work proceeds.
- 4.3.9 Walls shall be carried up regularly without leaving any part more than one metre lower than another unless the permission of the Engineer is first obtained. Work which is left at different levels shall be racked back.
- 4.3.10 The Contractor shall cut and fit block work as required, leave or form chases for edges of concrete slabs, steps, ends of partitions, etc cut chases for pipes, conduits, etc., and generally perform all cutting away for all trades. Wooden plates and door and window frames shall be bedded and exposed edges pointed in mortar and cramps shall be built in.

4.4 Load-Bearing Walls

- 4.4.1 Load-bearing walls shall be constructed in accordance with B.S.C.P 111 Part 2.
- 4.4.2 Where a horizontal or vertical joint is not solidly filled or where it is found that the Contractor has used blocks other than the blocks specified the whole panel of wall will be considered suspect and will be removed and rebuilt at the Contractor's expense.

4.5 Non Load- Bearing Walls

- 4.5.1 Non load-bearing walls shall not be constructed at the same time as the load-bearing walls but built at least two weeks after the roof or upper floor structure is completed. Toothing into load bearing walls will not be

permitted.

4.6 Protection of Finished Block work

- 4.6.1 The Contractor shall ensure that the finished block work walling is not damaged by subsequent operations.
- 4.6.2 The Contractor is to protect newly or partially built walling against it being dried out too rapidly by the sun's heat or from any other adverse climatic effects and is to follow the Engineer's instructions in this matter.
- 4.6.3 The Contractor shall in all cases cover all newly erected walling with hessian or other material approved by the Engineer and shall keep the same wet for at least three days.

4.7 Compressible Joint Fillers

- 4.7.1 Compressible joint fillers shall be used where specified at joints on drawings or requested by the Engineer. Filler shall be cut to exact widths and shall have all edges neatly trimmed. All fixing shall be strictly in accordance with the manufacturer's printed instructions.

4.8 Polysulphide Sealant

- 4.8.1 Gun quality sealant shall be used where specified on the drawing or where requested by the Engineer including external joinery and metal work bedded against block work or concrete. The colour shall be to the approval of the Engineer.
- 4.8.2 The primer shall be supplied by the same manufacturer as the sealant. The joints will first be thoroughly cleaned to the satisfaction of the Engineer and shall be primed before sealing with sealant. Application of these materials shall be strictly in accordance with the manufacturer's printed instructions.

4.9 Lintols

- 4.9.1 Prefabricated lintols shall comply with the requirements of B.S 5977, Part 2. All lintols shall be bedded on cement and sand mortar and the Contractor shall allow for a minimum bearing at each end of 150 mm.

4.10 Reinforcement

- 4.10.1 Plastic mesh reinforcement shall be used every connection to concrete.

4.11 Source of Material

- 4.11.1 All blocks for use in the works shall be obtained from a source approved by the Engineer. The Contractor shall not change same source without the written approval of the Engineer.

4.12 Storage of Materials

- 4.12.1 Cement shall be stored in a weatherproof ventilated housing off the ground and away from any source of water and dampness. These materials shall be stored in such a manner that they are used in rotation in order of delivery.
- 4.12.2 Sands shall be stored separately according to type, on clean concrete hard standings and protected from contamination.
- 4.12.3 Blocks shall be delivered to Site stacked and stored to permit ventilation and protected from rain, dampness and the like.
- 4.12.4 In the event that any materials for use in this Section deteriorate and become unusable due to inadequate and poor storage they shall be removed from Site as instructed by the Engineer and replaced at the Contractor's expense.

4.13 Block work below Ground Level

- 4.13.1 All blocks used in construction below ground level shall be solid.

5. ROOFING AND WATER PROOFING

5.1 General

5.1.1 Material shall be of the best quality and to the approval of the Engineer all in accordance with the relevant British Standards and Agreement Board Certificates.

5.1.2 Workmanship shall be to the highest standards and codes of practice.

5.2 Testing

5.2.1 The Contractor is to test, to the satisfaction of the Engineer, all areas of roofing, waterproofing, terraces, bathrooms, and the like for water penetration. These tests are to be carried out after the membrane has been laid.

5.2.2 The Contractor is to allow in his rates for such areas to be flooded with water, and left for a minimum of 48 hours.

5.2.3 On completion of roofing works the Contractor is to leave the roof in a sound and watertight condition, to the approval of the Engineer, and in a satisfactory state for handing over.

5.3 Guarantee

5.3.1 The Contractor is to provide the Employer with a written guarantee to cover improper materials or faulty workmanship for a period of 10 (ten) years from the date of issue of the Final Certificate at the completion of the maintenance period. The Contractor shall bear the cost of any of the consequential damage as is provided for in same guarantee. The text of the guarantee shall be to the Engineer's approval.

5.4 Protection

5.4.1 Finished and part finished surfaces shall be suitably protected to ensure no damage by other trades. Any roofing or waterproofing so damaged due to non-protection shall be removed and replaced at the Contractor's expense. The Contractor shall submit to the Engineer his proposed methods of protecting the various surfaces and locations prior to their completion or application of finishing layers, ie: tiling and the like.

5.5 Roofing

5.5.1 The roofing shall comprise the following layers:-

- 5.5.1.1 Concrete screed, density 650-800 kg/m³, minimum thickness 30mm laid to falls and cross falls to drainage outlets. The screed shall be laid in bays not exceeding ten square metres and 300 mm wide from the edge with joints between bays in 10mm thick compressible fibre material.
- 5.5.1.2 Supply and apply one coat of approved priming /bonding course as per manufactures' instruction.
- 5.5.1.3 4 mm elastomeric special polyester tropical grade modified bituminous felt, torch applied - black finish.
- 5.5.1.4 Skirting comprising waterproof membrane turned up and over fillet at roof perimeter up wall as per detail drawings. Allow for all two part polysulphide sealant and aluminium flashing.

5.6 Water Proofing

- 5.6.1 Prepare and apply two coats bitumen paint to all surface below ground level.
- 5.6.2 Apply primer and one layer self adhesive membrane, to Engineer's approval with end and side laps, applied as per the manufacturer's instructions to the concrete floors of all wet areas, including bathrooms, toilets, kitchens and the like including dressing into drainage outlets and the like, and turning membrane as skirting up all perimeter walls 300mm high and tucking into preformed groove.
- 5.6.3 As item (5.6.2) above to external walls of water tank and basement including one layer of 12 mm thick protection board (Bituminous impregnated).
- 5.6.4 As item (5.6.2) above to horizontal concrete surfaces and top of blinding as shown on drawings with 20mm thick screed protection layer over.

5.7 Water Tank Lining

- 5.7.1 The internal floor, walls and soffit of the water tank shall be treated with a waterproof coating. The lining shall be formed by the mixing of two components resulting in a plastic, thixotropic and easily applied compound suitable for use on horizontal and vertical surfaces. Further properties of the lining shall be nontoxic and contain no chloride or other corrosive salts which could cause blooming.
- 5.7.2 All surfaces shall be clean and sound and free of dust, loose particles, cement laitance, grease, rust and other contaminants prior to application all to the Engineer's approval. Absorbent surfaces, (concrete, renderings and plaster) shall be pewetted with clean water and during application the surface shall

be kept moist but free from standing water.

- 5.7.3 The lining shall be applied to the prepared surfaces in 2-3 layers, each layer not exceeding 1.5mm thickness. The total thickness shall not be less than 3mm overall. Curing shall be controlled so as to prevent the application drying out too quickly, particularly with respect to heavy winds and intense sunshine.
- 5.7.4 The Contractor shall submit to the Engineer for approval his water tank lining proposal and application of same shall be strictly applied in accordance with the manufacturer's printed instructions.
- 5.7.5 The Contractor to submit samples for Architect's approval.

6. METALWORK AND GLAZING

6.1 Generally

- 6.1.1 The Contractor is required to employ approved specialists to supply, or supply and erect all metalwork items. Working drawings are to be prepared and issued to the Engineer in quadruplicate for approval in good time to afford no delay to the project and in no case less than eight weeks before work needs to be put in hand.

6.2 Standards

- 6.2.1 Materials used in this Section shall comply with British Standards, the British Codes of Practice, DIN Standards, American Standards and American Society for Testing and.
- 6.2.2 Applicable provision of the following British Standards shall apply to these works as follows:-
- 6.2.2.1 Mild Steel shall comply with BS 4360, sections generally shall comply with BS 4: Part 1, hollow sections with BS 4848: Part 2 and angles with BS 4848: Part 4. Steel plate and sheet shall comply with BS 1449: Part 1 and steel tubes to BS 1775.
 - 6.2.2.2 Stainless Steel Tubes shall comply with BS 3014, and stainless steel plate with BS 1449: Part 2.
 - 6.2.2.3 Aluminium alloy extruded sections shall comply with BS 1161 or BS 1474 and aluminium alloy drawn tube with BS 1471. Anodising process when applicable to comply with BS 3987.
 - 6.2.2.4 Brasswork as indicated on the drawings shall comply with the various appropriate Standards.
 - 6.2.2.5 Fastenings unless otherwise specified shall be of the same metal as the item being fixed, with matching coating or finish. Wood screws shall comply with BS 1210. Bolts, Screws and nuts to BS 4190, machine screws and nuts to BS 4138 and self-tapping screws to BS 4174.
 - 6.2.2.6 Plugs shall be proprietary fibre plastics or other approved type.
 - 6.2.2.7 Bitumen solution for cold application shall comply with BS 3416, Type 1.

6.3 Finished Coating

6.3.1 General

- 6.3.1.1 The finished coating shall be as stated on the Drawings and applied strictly in accordance with the manufacturer's instructions.
- 6.3.1.2 The colour of the coating shall be selected from available ranges if not stated elsewhere in these Documents. The Contractor shall offer samples for approval prior to the final selection and the manufacturer of these elements.

6.3.2 Anodised coating

- 6.3.2.1 The aluminium anodising shall comply with BS 3987 and be integral colour hardcoat anodising 550kp/mm² hardness, minimum 60 microns thick.
- 6.3.2.2 The colour of anodising shall be as described on the drawings. Samples of colour including limits of colour variation shall be submitted to the Engineer for his approval before work commences. The Engineer reserves the right to reject the products of any supplier who cannot guarantee a reasonable limit of colour variation, the acceptable limit of variation being at the Engineer's discretion. (Alucobond Company: <http://www.alusuisse-comp.com/>)

6.3.3 Polyester powder coating

- 6.3.3.1 All aluminium sections that are to receive a polyester powder coating shall be given a caustic etch followed by an anodix oxide treatment to obtain an Architectural class 1 anodic coating. Anodisation should be not less than 60 micron thickness.
- 6.3.3.2 All aluminium works shall be finished in coloured electrostatic polyester powder coating as per DIN standard 53151, 53152, 53153, 53156 or equal and approved to Ral colour subject to the Engineer's approval. (Alucobond Company: <http://www.alusuisse-comp.com/>)

6.3.4 Fluorocarbon finish (PVF2 or Kynar500)

- 6.3.4.1 Aluminium panels to be fluorocarbon finished to AS 2728 Category 3. Highly corrosion resistance high film build primer on both sides with a nominal film thickness of 25microns. Finish coat with a nominal thickness of 20microns to contain at least 70% Kynar500 or Hylar5000 resin. (Alucobond Company: <http://www.alusuisse-comp.com/>)

6.3.5 Epoxy Paint Coating

- 6.3.5.1 Mild steel dipped galvanised to be spray coated with Epoxy based paint shall be factory applied in two layers, primer coat

0.3 mils dry film thickness and finished colour coat minimum 1.0 mils dry film thickness, minimum overall thickness of 1.3 mils dry film thickness. Inside corners, channels and the like shall be visually covered to the extent possible. The Engineer shall select the colour from the range available.

- 6.3.5.2 The coating shall be applied to properly cleaned and pre-treated galvanised steel sections. Application shall be by approved applicators and the Contractor shall provide certified details of same. The pretreatment and application of the coating shall conform to all ASTM, BS, DIN Standards and the like as stated in the Supplier's printed Specifications.

6.3.6 Coating thickness

- 6.3.6.1 As and when instructed by the Engineer, the Contractor shall provide certificates from independent laboratories that the minimum thickness as stated in these Documents has been applied to the aluminium sections. Failure to provide such information shall result in the complete installation being rejected and replaced at the Contractor's expense.

6.3.7 Dissimilar materials

- 6.3.7.1 All aluminium surfaces that are to be in contact with cured concrete, mortar, steel and other metals shall have the contact surfaces protected wherever they may entrap moisture or corrosive elements. Metals that are to be in contact with mortar or concrete shall be protected with a two coat bituminous coating.
- 6.3.7.2 Prime paint steel parts of anchors, anchor inserts, reinforcement, supports, and all parts after field welding or bolting with zinc chromate. Minimum dry film thickness of 1 mil for zinc chromate.

6.4 Samples

- 6.4.1 Submit duplicate samples of all finished materials for approval by Engineer. The samples will show the full range of finishes and mechanical properties to be expected in the finished product. Where physical samples would otherwise be too large, examples will be given that can be readily inspected locally, or the Contractor will provide facilities for the Engineer's inspection at the Contractor's expense.
- 6.4.2 Unless specifically called for, size and form of each sample shall be as directed by the Engineer.

6.5 Sealing Joints

- 6.5.1 The Contractor shall ensure that joints are dry and remove all loose material,

dust and grease.

- 6.5.2 Joints shall be prepared in accordance with sealant manufacturer's recommendations using recommended solvents and primers where necessary.
- 6.5.3 Adjoining surfaces which would be impossible to clean if smeared with sealant shall be masked.
- 6.5.4 Backing strips shall be inserted in all joints to be pointed with sealant.
- 6.5.5 When using backing strips, the Contractor shall not leave gaps and shall not reduce depth of joint for sealant to less than the minimum recommended by the manufacturer.
- 6.5.6 Cavities shall be filled and jointed with sealant in accordance with the manufacturer's recommendations.
- 6.5.7 Sealant shall be tooled to form a smooth flat bead.
- 6.5.8 Excess sealant shall be removed from adjoining surfaces using cleaning materials recommended by the sealant manufacturer, and shall be left clean.

6.6 Glazing

- 6.6.1 Glass shall be in accordance with British and American Standards. It is to be entirely free from waves, scratches, bubbles, air holes, smoke wanes or similar defects.
- 6.6.2 The Contractor shall produce on request all invoices or advice notes from suppliers to confirm that the glass is of the standard specified.
- 6.6.3 Any scratched, broken or otherwise defective glass is to be removed and replaced by the Contractor at his cost during or on completion of the Works.

6.7 Glazing Materials

6.7.1 General

- 6.7.1.1 The Contractor shall submit representative samples of all glass he proposes to install in the Works. On receipt of the Engineer's approval of same the Contractor shall commence the procurement of the glass.

6.7.2 Sheet Glass

- 6.7.2.1 Sheet glass shall be flat-drawn clear sheet glass complying with BS 952, Section 1, ref 4(a), 'Ordinary Glazing Quality'.

6.7.3 Reflective (Mirror) Glass

6.7.3.1 Sheet or float glass of 6mm thickness in according to the colour specified by the Architect . Total solar heat rejection shall be 75% to 78%. Edges shall be cut clean to avoid weak spots from which thermal cracks may develop. Special care is needed in glazing solar control glasses to accommodate thermal movement. The edge clearances must be at least 3mm all round for panes where neither dimension exceeds 750mm and 5mm where one dimension is greater. Similarly at least 3mm must be allowed between the faces of the glass and the upstands of rebates and glazing beads

6.7.4 Plate Glass

6.7.4.1 Plate glass shall be cast, rolled or drawn glass ground and polished on both surfaces complying with BS 952, Section 1, ref 6a(1), 'Glazing Quality for Glazing'.

6.7.5 Obscured Glass

6.7.5.1 Obscured glass shall be figured rolled glass complying with BS 952, Section 2, ref 14b of approved type.

6.7.6 Wired Glass

6.7.6.1 Wired glass shall be polished Georgian wired glass having both surfaces ground and polished and with square mesh inserted during rolling complying with BS 952, Section 4, ref 21b.

6.7.7 Mirrors

6.7.7.1 Mirrors shall be of uniform thickness, free from waviness, air bubbles and the like. Representative samples of mirror shall be submitted for the Engineer's approval. The mirror glass shall be clear and silvered by nitrate precipitation, protected by copper plating with a protective plastic coating on the reverse side. The mirrors shall be 6 mm thick and cut to sizes as shown with ground and polished edges. The mirrors shall be set on 20 mm thick plywood backing plugged and screwed to wall.

6.8 Glass Openings

6.8.1 The glass framing shall both structurally support and adequately cushion the glass. To prevent mechanical and thermal stresses on the glass, the framing system shall provide openings that are within the tolerances for squareness, corner offset and bow. These tolerances are listed below.

6.8.1.1 Squareness - 3mm difference in lengths of the diagonals.

6.8.1.2 Corner Offsets - 0.8mm maximum offsets at corners.

6.8.1.3 Bow - 1.6mm bow in a 1.22m length of frame.

- 6.8.2 If the variations from these tolerances are anticipated, details of same shall be advised to the Engineer. If site conditions are found to be outside these tolerances corrections must be made before the openings are glazed.

6.9 Glass Installation

- 6.9.1 Workmanship shall generally be in accordance with CP 152 and respective British Standards.
- 6.9.2 The glass is to be delivered to the site with adequate protection to prevent damage and where possible it is to be fixed in position immediately after delivery. When fixed the Contractor is to take all necessary precautions to prevent damage during succeeding building operations and will be entirely responsible for the replacement of any broken or damaged glass at his own cost.
- 6.9.3 The Contractor is to be solely responsible for determining the exact sizes of glass required, including a tolerance of 2mm to each edge and he is recommended to check the necessary dimensions on site.
- 6.9.4 No glazing is to be carried out until rebates have been painted with primer. Glazing beads as applicable are also to be primed before fixing.
- 6.9.5 All mastic is to be neatly struck off to agree exactly with site lines inside and out.
- 6.9.6 Rates are to include for all necessary spriggs, clips, setting blocks, location blocks and distance pieces and for taking off and later re-fixing loose beads.
- 6.9.7 Glass apertures in timber doors are to be bedded in chamois leather glazing strip, black ribbon velvet or P.V.C. glazing strip to the approval of the Engineer.

6.10 Cleaning

- 6.10.1 All glass shall be thoroughly cleaned and polished on both sides and all paint spots and the like completely removed to the satisfaction of the Engineer.

7. CARPENTRY & JOINERY

7.1 -General

- 7.1.1 Joiner's work shall be carried out in accordance with the drawings and the principles of first class construction.
- 7.1.2 Full details of the timber to be used are to be submitted to the Engineer and the quality for any purpose is to be approved before any timber is delivered to site.
- 7.1.3 The timber is to be of the best quality available having due regard for the purpose for which it is required and it is to be seasoned to a moisture content of 14%-15% before transportation.
- 7.1.4 The Contractor is to take a site reading to determine the moisture content of all joinery by Moisture Meter. Documentation is to accompany each batch shipped to verify the moisture content. Without such documentation the whole batch will be rejected.
- 7.1.5 The Engineer shall reject all unsound timber caused by decay, insect attack, sapwood, splits, shakes, and waney edges, pith pockets, together with large, loose or dead knots.
- 7.1.6 Unless stated otherwise, sizes shown on drawings are finished sizes.

7.2 Timber Grades

- 7.2.1 All timber shall be of grade C27 (BS) or higher. Red Meranti may be considered to be approximately equivalent to C27. Where other timbers are necessary they are specified on relevant drawings.

7.3 Timber for Carcassing

- 7.3.1 Timber for carcassing generally is to be Red Meranti (prime grade), free from decayed or loose knots, splits and any sign of fungus/live insect attack, and to the approval of the Engineer.
- 7.3.2 The structural timber wood is to be straight, close grained, with not less than eight annular rings to 25 mm. Unless otherwise described all sawn members are to be of a permissible species which has been visually or machine stress graded and which meets the requirement of BS 4978 may be used with the

Engineer's permission.

7.4 Softwood for Joinery

- 7.4.1 The timber for joinery is to be Red Meranti (prime grade) or other equal and approved, selected for joinery work.
- 7.4.2 Joinery timber is to be selected with due regard for the particular purpose for which it is to be used, Appendix A of BS 1186 (Part I) being used as a guide.
- 7.4.3 Where indicated on the drawings, softwood for first or second fixings is to receive a paint or stain finish on exposed surfaces.

7.5 Hardwood or Joinery

- 7.5.1 Hardwood for joinery is to be first quality Balau unless otherwise stated, and it is to be suitable for its intended use in accordance with Appendix B of BS 1186 (Part I).
- 7.5.2 Hardwood for joinery is to be quarter sawn unless otherwise indicated and is to show a straight and regular grain throughout without shakes or other defects which would reduce the mechanical or physical properties of the timber. Timber in the finished joinery is to be free from wooly texture, soft heart, sapwood, splits, shakes, dote, all evidence of fungus/insect attack and all faults caused by compression failures. There are to be no waney edges. It is to be free from unsound knots and there are to be no knots of any description on exposed faces, unless specifically agreed. Plugging or piecing in will not be permitted.
- 7.5.3 Colour of hardwood throughout is to be consistent and to the approval of the Engineer.

7.6 Preservative Treatment

- 7.6.1 The preservative treatment to all timber shall comply with the requirements of BS 5268 or equivalent for any species not listed therein. The Contractor shall provide a certificate of assurance that treatment has been carried out as specified. Any ends cut after treatment are to be given two coats of preservative. Factory fabricated timber and components shall be treated therein.

7.7 Fire Resistance And Flame Retardants

- 7.7.1 All timber, plywood and boarding shall comply with the requirements of BS

476 and 5669 in respect of fire resistance and the application/treatment of flame retardants. The Contractor shall provide a certificate of assurance that such compliance/treatment has been carried out as specified. (PyroGuard: <http://www.frtw.com/>)

7.8 Plywood

- 7.8.1 Plywood generally is to comply with BS 1455, and is only to be obtained from a manufacturer approved by the Engineer.
- 7.8.2 The plywood bonding is generally to be type WBP, except where otherwise stated. The Contractor is only to use plywood of the required thickness, and under no circumstances is he to make up thickness by gluing together sheets of thinner plywood.
- 7.8.3 The surface grading is to be Grade 1 where to receive clear finish and Grade 2 elsewhere, unless otherwise described. The Contractor is only to use a fine tooth saw when cutting plywoods.

7.9 Plastic Laminate

- 7.9.1 Decorative plastic laminate (melamine) sheeting shall comply with BS 3794 Class 1.
- 7.9.2 The sheeting shall be capable of being post formed at the edges without cracking, breaking, chipping or the like. Under no circumstances shall edges be stuck on but formed from whole sheets covering the main body of the item of work.
- 7.9.3 Only whole sheets shall be used and fixing of the sheeting shall generally be as stated above for Veneers. VGS class laminate shall generally be used for doors while HGP class laminate shall be used for all other applications including post forming. Selection of laminate and choice of colour all to the approval of the Engineer.

7.10 Hardboard

- 7.10.1 Hardboard is to be standard quality in accordance with BS 1142 Part 2.

7.11 Nails and Screws

- 7.11.1 Nails are to comply with BS 1201 and screws with BS 1210. They are to be of the appropriate approved type for their intended use.

7.12 Metalwork

- 7.12.1 Metalwork fixings are to be galvanised and of a make and pattern approved

by the Engineer.

7.12.2 Bolts are to comply with BS 4190.

7.12.3 Fixing accessories are to comply with BS 1494.

7.12.4 Timber connectors are to comply with BS 1579.

7.12.5 Expanding bolts to the approval of Engineer.

7.13 Adhesives

7.13.1 Adhesives are to be synthetic resin type complying with BS 1204 Part 1, and they are to be type WBP.

7.14 Access Panels and The Like

7.14.1 The Contractor is to provide access doors, panels and traps to the complete satisfaction of the Engineer, wherever access may be necessary in order to maintain the services within the building.

7.14.2 Accesses which are likely to be used regularly are to be formed with hinged lockable panels; those used irregularly are to be capable of being removed by releasing screws or clips.

7.15 Workmanship

7.15.1 Joinery shall comply with BS 1186 Part 2 and CP 112 for structural carpentry, and where possible shall be fabricated in a manufacturer's shop prior to delivery. It shall be accurately, properly and soundly constructed with all moulds and arrises clean and sharp. Joinery shall be protected from damage during storage at Site and throughout the construction period subsequent to fixing.

7.15.2 The terms "frame" or "framed" or "framing" mean work put together by proper carpentry or joinery joints, such as morticing and tenoning, dovetailing, dowelling, etc., and the joints are to be as shown, specified or directed. Butted and screwed or nailed joints or halved joints and the like will not be deemed framed and will not be accepted for framed work.

7.15.3 Fixing of all joinery work, including fillets, architraves, frames, glazing beads and the like shall be by means of screws. Nailed work will not be permitted.

7.15.4 Screw heads in work to be painted shall be countersunk and stopped. Screw heads in wood to be oiled, varnished or polished shall be pelltated, with the grain of the pelltat in the same direction as the grain of the member.

7.15.5 Unless otherwise described, work described as "plugged" shall be fixed by drilling holes in the wall or floor, plugging with "Plastic Plugs" well rammed

in and fixing the member with screws. Centres of the fixings must not exceed those necessary to provide adequate support, and in any case must not exceed 600 mm.

7.16 Packaging and Storage

- 7.16.1 All timber and composite items are to be polythene wrapped at 14% moisture content before transportation.
- 7.16.2 The timber is to be properly stored and protected on site until immediately prior to fixing when the polythene is to be removed and the timber stacked above the ground in the shade.
- 7.16.3 The Contractor is to ensure that the timber is covered in wet weather and uncovered in dry weather and is to replace any damaged or otherwise affected items at his own expense.
- 7.16.4 All factory fabricated units and components shall be stored in their packing until fixing of same commences to ensure that damage is kept to a minimum.

7.17 Doors/Windows

- 7.17.1 Doors shall be properly fitted to give a uniform clearance of not more than 3 mm all round and hinges shall be let into doors and frames.
- 7.17.2 Flush doors are to be constructed in accordance with BS 459 Parts 1 and 2. All edges are to be lipped with hardwood lipping tongued into the edge of the door.
- 7.17.3 Flush doors generally shall be solid core flush faced with a veneer finish prepared to receive decoration.
- 7.17.4 The core of solid core flush doors shall be constructed of longitudinal laminations of precision planed timber, butt jointed and glued with resin based adhesive under hydraulic pressure, the whole forming a rigid, fire resistant raft.
- 7.17.5 All doors, solid/semi solid core, shall be constructed with blocking pieces to receive hinges, door closers and other ironmongery as specified.
- 7.17.6 Where flush doors are to have an observation panel or are to receive a grille panel the framing of the door must be designed to suit the required size of panel and must be properly framed and rebated around all sides of the panel.

Loosely fixed hardwood glazing beads of adequate size are to be provided with the door when delivered to the site for removal and later final fitting.

- 7.17.7 Where flush doors are to have rebated or rounded stiles the lippings at the edges must be increased sufficiently to allow for these labours. Cutting rebates or forming roundings on standard sized lippings will not be permitted.
- 7.17.8 Fire doors shall have a 2 hour fire rating unless otherwise described, and shall generally be constructed in accordance with the relevant British Standard or DIN Standard. All fire doors shall be fixed with an intumescent strip insert in their frame. (Adams rite fire doors: <http://www.adamsrite.com/>)

7.18 Protection, Finishing And Re-Examination

- 7.18.1 All the wood for joinery works, whether it is to be painted or left clear finished, shall be supplied properly planed and rubbed down.
- 7.18.2 The joinery shall be properly protected during fixing and work by other trades, especially frames and door linings which may require temporary casings.
- 7.18.3 The frames shall be fitted with a temporary threshold to retain frame shape which can be removed before floor finishes are laid.
- 7.18.4 Units supplied "pre-finished" (veneered doors, pre-painted doors etc) shall be supplied with an appropriate wrapping, and the Contractor shall repair or replace any defective work, no matter from whatever cause, in order to hand over the works in perfect condition.
- 7.18.5 After the setting, placing and fixing of the joinery, the Contractor shall examine all the works and ensure that they are fixed correctly. Until the issue of the Practical Completion Certificate and handover of the entire work, the Contractor shall replace at his own expense, all missing or defective parts.
- 7.18.6 At the end of the works, the Contractor shall check all opening units and their proper functioning, and shall grease all moving parts, if necessary.
- 7.18.7 After handover, the Contractor shall maintain his work and shall, on request, carry out all easing and adjustments as required.
- 7.18.8 In the case where defects appear especially, twisting of doors and the like, the Contractor shall rectify such defects at his own expense.

7.19 Screens

- 7.19.1 Screens shall be manufactured from solid hardwood to patterns and designs as described and directed by the Engineer. All screens shall be manufactured in accordance with the requirements of this section of the work.

7.20 Ironmongery

7.20.1 General

- 7.20.1.1 All ironmongery shall be selected for the appearance and performance required and shall be obtained from a well known reputable manufacturer and shall bear the stamp of the manufacturer. Unless specified otherwise all ironmongery shall be supplied from the same manufacturer.
- 7.20.1.2 The Contractor shall not use in the works types or classes of ironmongery other than those specified except with approval in writing of the Engineer.
- 7.20.1.3 The type, location, quality and finish of ironmongery shall be as shown on the drawings and the Contractor shall submit for approval a comprehensive schedule of ironmongery covering all items required to complete the works. This schedule shall give catalogue references and locations for all ironmongery.
- 7.20.1.4 All screws used for fixing ironmongery shall be supplied and shall be of the correct type, material, finish, size and shape to the satisfaction of the Engineer.
- 7.20.1.5 The base metals for finishes shall be as follows:
 - aluminium finish : aluminium
 - nickel plated : bronze or brass
 - stainless steel finish : stainless steel

7.20.2 Workmanship

- 7.20.2.1 All ironmongery shall be carefully wrapped and protected until the completion of the work and any items or parts which are damaged shall be replaced at the Contractor's expense before hand-over of the works.
- 7.20.2.2 Any locks with steel components which are to be used in or near damp rooms shall be hot galvanised and painted before fixing.
- 7.20.2.3 All ironmongery shall be securely fixed or housed and all rebates, holes, etc., to take ironmongery shall be neatly and cleanly executed.
- 7.20.2.4 All hinges shall be carefully housed or let into the hinged elements and to the frames.
- 7.20.2.5 Intumescent paste shall be applied around all ironmongery to be fixed on fire doors.
- 7.20.2.6 All fitting shall be removed before starting any painting operations and refixed in place after all painting work is completed and approved by the Engineer.

- 7.20.2.7 The Contractor shall check and adjust all ironmongery, and oil or grease moving parts to ensure good performance.
- 7.20.2.8 On completion, all locks, catches and similar types of ironmongery shall be properly cleaned, tested and oiled or greased.

7.20.3 Suiting

- 7.20.3.1 Locks shall be selected from a range of ironmongery having compatible keys. It will be a requirement that the locks shall be so arranged as to accept a common master key and sub-divided so as to offer a number of sub-master keys.
- 7.20.3.2 All locks shall be provided with three keys, which on completion of the work shall be clearly and securely labelled with 50 X 20 mm metal tags securely fixed to the keys and delivered to the Engineer.

7.21 Service Ducts and Access Panels

- 7.21.1 Provide service ducts and access panels to sanitary appliances and fittings, dry riser, electric panel and the like as shown on detailed and location drawings. Ducts and panels shall generally be demountable comprising plywood board fixing to galvanised steel frames with countersunk machine screws. All framing to be galvanised and painted. Outside face of ducts and panels shall be finished to receive the adjacent wall finish. Externally located ducts and panels shall be constructed accordingly using only properly treated materials.
- 7.21.2 Size of service ducts and access panels shall be as shown. Contractor to provide details of proposed framing and fixing details for Engineer's approval prior to commencing work.

7.22 Drywall Partitions

- 7.22.1 The drywall partitions shall comprise and be constructed using the following specifications:
- 7.22.2 Materials
 - 7.22.2.1 All materials to be of Gyproc from British Gypsum or equivalent and approved.
 - 7.22.2.2 Drywall partitions shall be installed according to the manufacturer's instructions. All materials to have Engineer's approval prior to commencement of Works.

- 7.22.2.3 Internal drywall partitions will have a total thickness of 75mm, 0.5 hour fire resistance and 44 decibel average sound reduction index. Two hour resistance drywall partitions shall include fire resistant lining to give specified rating.
- 7.22.2.4 Drywall partitions having glazing vision panels shall consist of two 6 mm clear monolithic float glass with H.W frame and beading covering the full width of the wall.

7.22.3 Metal Studs

- 7.22.3.1 Metal studs and channels of 48 mm width to be made of light weight cold rolled, galvanized mild steel to comply with BS 2989 and BS 2994. Vertical studs shall be installed at 600 mm maximum centers.
- 7.22.3.2 Damp-proof membrane will be inserted under the floor channel.

7.22.4 Plasterboards

- 7.22.4.1 Gypsum plasterboards of 12.7 mm thick to comply with BS 1230, shall be screwed to the studs, carefully cut and jointed.
- 7.22.4.2 Plasterboards towards wet areas such as bathrooms, toilets and kitchens will be fixed 10 mm above floor level to allow for caulking.
- 7.22.4.3 The lining shall be skimmed with taped joints to receive finish.

7.22.5 Insulation

- 7.22.5.1 Insulated drywall shall receive a 40 mm resin bonded glass wool slabs, 68 kg/m³, to be installed between the plasterboard linings.

7.22.6 Services

- 7.22.6.1 Prior to installing insulation and plasterboard on second side, all pipes, switchboxes, etc. will be fixed, inspected and tested if required.
- 7.22.6.2 Heavy fixtures such as lavatory cisterns and hand basins shall have a timber frame inside the partition with vertical and horizontal members to take the required fixings.

8. STRUCTURAL STEELWORK

8.1 Design

8.1.1 The design of structural steelwork shall be in accordance with BS 449.

8.2 Material Properties

8.2.1 Steel for rolled sections, plates and bars shall comply with BS 4360 Grade 43C.

8.2.2 Dimensional properties, tolerance and rolling margins shall conform to the relevant British Standards.

8.2.3 The condition of steel for fabrication shall be Grade C of Swedish Standard 05 59 00.

Steel work shall be fabricated and erected by competent, experienced persons and shall generally conform to B.S. 449 - Part 2 - "Specifications for the use of structural steel in buildings"

8.2.4 Black bolts and nuts shall comply with BS 4190 metric.

8.2.5 Washers shall comply with BS 4320.

8.2.6 High strength friction grip bolts shall comply with BS 4395 Part 2.

8.3 Testing of Materials

8.3.1 The Contractor may be required to perform tests as instructed by the Engineer and submit test certificates for the materials to be used in the work. The tests shall include the following in accordance with BS 4360.

- ◆ Chemical analysis
- ◆ Tensile tests
- ◆ Bend tests

◆ Flattening tests

8.3.2 The tests shall be carried out by an approved testing authority and notice shall be given to the Engineer of the intended execution of any such test. The cost of such tests shall be borne by the Contractor.

8.3.3 If any sample fails a test, the consignment it represents may be rejected in part or in whole at the Engineer's discretion.

8.4 Fabrication Standard

8.4.1 The work of fabrication and erection shall comply with the requirements of BS 449. Contractor shall furnish samples of the components and obtain approvals for the same before proceeding with the fabrication

8.4.2 Fabrication accuracy shall be within the following limits:

- ◆ Length : 3 mm
- ◆ Twist and Deviation : 1 in 1000

8.5 Detailing of Connections

8.5.1 Detailing of connections shall ensure that inaccessible pockets/gaps are avoided. In this respect back-to-back angles with spacers, and similar details which would prevent full accessibility for painting, are not acceptable.

8.5.2 Where cope holes are required to allow completion of butt welding they shall be of adequate size to allow fillet welding to seal the connection while still allowing full accessibility for subsequent painting.

8.5.3 Sniping of stiffeners at the root radii of rolled members is not acceptable. Stiffeners shall be cut to the required profile to fit closely into all such radii, and seal welded in accordance with Clause 9.7.

8.6 Submissions

8.6.1 Shop drawings for approval shall be submitted at least four weeks before starting fabrication. Material shall not be ordered nor fabrication commenced until shop drawings are approved in writing by the Engineer.

8.6.2 The Contractor shall prepare and submit details of erection procedures at least four weeks before commencement of steel erection.

8.7 Welding

8.7.1 Metal-arc welding of steel to BS 4360 shall be in accordance with the requirements of BS 5135. If galvanized steel is used, before welding, galvanized layer should be removed from the welding area. Anticorrosive paints to be applied in the joints after the welding.

8.7.2 Run-on/Run-off plates shall be used during butt welding.

8.7.3 Fillet welds shall be continuous to form a complete seal where structural elements join or abut.

8.8 Electrodes for Welding

8.8.1 The Contractor shall obtain approval for the types of electrodes proposed for use. Welding electrodes shall give a weld deposit with mechanical properties not less than the minimum specified for the parent metal; they shall comply with BS 639. Hydrogen-controlled electrodes shall be used for butt-welding of steel over 25mm thick.

8.9 Welding Operators

8.9.1 Welders employed on the work shall be tested to BS 4871 and BS 4872 Part 1. Welding shall be carried out under the supervision of a competent welding technologist and the test pieces shall be tested to BS 4870.

8.10 Testing of Welds

8.10.1 The Contractor shall make radiographic examination of butt welds in accordance with Section 8 of American Petroleum Industry (API) Standard 1104 and carry out dye-penetrant tests in accordance with BS 4416.

8.10.2 In general 10% of the length of each butt weld shall be radio graphically inspected and 10% shall be tested using penetrant, 5% of the length of each fillet weld shall be tested using penetrant. The location of lengths to be tested shall be as directed.

8.11 Site Welding

8.11.1 The Contractor may, subject to prior approval, use site welding as an alternative to bolted connections.

8.11.2 Site welded joints shall be inspected by radiography in accordance with Section 8 of API Standard 1104. Initially 100% of each but weld shall be inspected.

8.11.3 If approved the number of inspections may be subsequently reduced.

8.11.4 Finished welds shall comply with Section 6 of API Standard 1104. Defective welds shall be cut out, remade, and retested as approved.

8.12 Bolted Connections

8.12.1 The threaded portions of bolts shall be outside the parts bolted together and the ends shall protrude by at least one complete thread and by not more than three complete threads beyond the outer face of the tightened nut.

8.12.2 Holes shall not be distorted or enlarged by the use of drifts.

8.12.3 High strength friction grip bolts shall be fitted in accordance with BS 4604 Part 2.

8.12.4 The use of load-indicating washers shall be in accordance with the manufacturer's recommendations.

8.13 Transportation and Storage

8.13.1 Steelwork and protective coating shall be protected from damage during packing, handling, transportation and storage.

8.13.2 The Contractor shall ensure that members are not subjected to greater stresses than those allowed in BS 449 during fabrication, transportation, storage and erection.

8.13.3 Stored members shall not be in contact with each other and shall be clear of the ground.

8.14 Damaged Material

8.14.1 Steelwork deemed to be damaged beyond repair in transit shall be replaced.

8.14.2 The Contractor shall obtain prior and final approval for remedial work to damaged material.

8.15 Galvanising

8.15.1 Galvanising of steelwork if required shall be carried out after fabrication is complete. Steelwork required to be galvanised shall be pickled in dilute hydrochloric acid then washed, fluxed and stoved, and coated with zinc by dipping in a bath of molten zinc. Components shall be immersed in the bath only for a period sufficient to attain the temperature of the bath and shall be withdrawn at a suitable speed so that a minimum coating of 610 g/m² of surface (85 microns min. DFT) is achieved. Components shall be covered evenly on all surfaces.

8.15.2 Items described as heavily galvanised shall be grit blasted prior to galvanising and receive a minimum coating of 1000 g/m² of surface (140 microns min. DFT).

8.15.3 Lightweight gauge metal work shall be galvanised by the hot-dip process as specified in BS 3083 or BS 2989.

8.15.4 Contact between galvanised steel members and aluminium surfaces shall be prevented by means of an approved insulating layer.

8.15.5 Galvanised steelwork shall receive specified paint treatment and shall be cleaned, degreased, abraded and etch-primed beforehand.

8.16 Preparation of Steelwork for Protective Treatment

8.16.1 Surfaces shall be cleaned to BS 4232 before any protective treatment is commenced. Steelwork shall be degreased and shot or grit blasted to SA 2½ quality standard with a surface amplitude of 50-75 microns to remove rust and mill scale; dust and debris shall be removed by vacuum cleaner, compressed air or brush. Site welds and adjacent steel work shall be blast cleaned and similarly prepared. Surface defects shall be removed in accordance with BS 4360.

8.16.2 Regular mill scale detection tests shall be made using the Copper Sulphate method.

8.16.3 Blasting operations and painting processes shall be segregated.

8.17 Painting Generally

8.17.1 Paint shall be applied by brushing or spraying in accordance with the manufacturer's permitted percentages. Viscosity tests shall be carried out on random samples of mixed paints as directed. Brushes stored in thinners shall be worked out to remove thinners before re-use.

8.17.2 Painting shall not be carried out when the steelwork temperature is below 4° C or above 38° C, or less than 3° C above dew point, nor when the relative humidity is above 80%.

8.17.3 Stripe coats shall be applied to welds and steel edges before painting.

8.17.4 Strong paint films shall be achieved on all cleats, arrises, boltholes, bolt heads and the like.

8.17.5 Protective treatment other than the site-applied coatings shall be applied under factory conditions in an enclosed shop. Completed coats shall be checked for continuity by a low-voltage wet-sponge holiday detector and for thickness by an Elcometer.

8.17.6 If a required film thickness is given it shall be the minimum dry film thickness (DFT) as measured by an Elcometer; the Elcometer shall be calibrated for each coating by the use of a shim of known thickness placed upon the shot-blasted blank or the underlying coat, and the shim shall correspond with the theoretical film thickness of the surface of coating shall be applied in accordance with the rate of coverage recommended by the manufacturer having regard to the surface profile of the steel and the conditions of application.

8.17.7 Sample plates shall be prepared for approval and shall thereafter be adopted as the standard to be achieved in the finished work.

8.17.8 The Contractor shall prevent dust and dirt coming into contact with freshly painted surfaces.

8.17.9 Before the site painting coats are applied, the surfaces shall be washed with clean water to remove salt and other impurities.

8.17.10 Paint shall not be applied to the embedded portions of metal items except for the portions within 75mm of the finished concrete surface.

8.18 Application Of Protective Layers

8.18.1 Blast-cleaned surfaces shall be kept dry and over-coated within 4 hours of the start of cleaning (2 hours for outdoor blast-cleaning). They shall be treated in accordance with the protective treatment schedule, except faying surfaces for HSFG connections.

8.19 Bolts

8.19.1 Bolts, including friction-grip bolts, nuts and washers shall be hot-dip spun-galvanised in accordance with BS 729. The threads of nuts may be re-tapped as provided for in that Standard.

8.19.2 Faying surfaces of high-strength friction-grip connections shall be blast cleaned to Sa 2½ quality standard, masked within two hours to exclude air and only exposed just before bolting-up. Paint or contaminants shall not be allowed on faying surfaces.

8.20 Materials for Steel work Protection

8.20.1 Materials for steelwork protection shall be from a reputable, certified manufacturer.

8.21 Schedule of Protective Treatment

8.21.1 Alkyd Finish Paint System

8.21.1.1 Protective treatment to steelwork shall be in accordance with the following schedule:

TREATMENT Min. DFT	microns
Blast clean to Sa 2½ quality standard surface amplitude 50-75 microns	-
Holding primer	(20)
Zinc phosphate, epoxy primer	75
Micaceous iron oxide epoxy	100
Oil modified alkyd undercoat	40

Oil modified alkyd high gloss finish (colour as directed)	40
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- 8.21.1.2 Damaged paint work shall be blast-cleaned if bare metal is exposed or corrosion is present. If the primer is intact the surface shall be prepared by power wire-brushing. The prepared surface shall be protected with coatings 4, 5 and 6, each to the minimum DFT.

8.21.2 Galvanised plus Alkyd Finish Paint System:

TREATMENT Min. DFT	microns
Degrease galvanised surfaces with G.500 water rinsable cleansing solution	-
Lightly abrade	-
Check for paint acceptability 'T wash' mordant solution	-

- 8.21.2.1 Paint application shall not proceed until this check indicates, by the development of a black conversion coating, that the entire surface is suitably prepared to receive paint.

Rinse with fresh water and dry	-
Metallic lead primer	50
Micaceous iron oxide epoxy	-
Oil modified alkyd undercoat	-
Oil modified alkyd high gloss finish (colour as directed)	40

- 8.21.2.2 Damaged paintwork shall be blast- cleaned if bare metal is exposed or corrosion is present. If the primer is intact the surface shall be prepared by power wire-brushing. The prepared surface shall be protected as follows:

- 8.21.2.3 Where primer is intact:

- Touch up with coatings 6, 7 & 8 each to the min. DFT

- 8.21.2.4 Where blast cleaning is necessary:

- Apply two coats of metallic lead primer to a minimum DFT of 150 microns
- Touch up with coatings 7 & 8, each to the minimum DFT

8.22 Painting of Galvanised Bolts Etc. After Erection

- 8.22.1 Following erection galvanised boltheads, bolt ends, nuts and washers shall

be degreased with G.500 cleansing solution and abraded and painted to the specification of adjacent steelwork.

8.23 Erection

8.23.1 The Contractor shall unload all materials and plant on site and shall provide tackle plant and packing necessary for the erection of the steelwork including any temporary bracing. No joints shall be finally connected together until all the steel work members, elements and the like have been accurately aligned. Drift pins shall be employed only to bring together parts for assembly and must not to be used to distort the work. Stanchion bases shall be levelled up by the use of laminated steel packs placed at the corners of the base plates. When the stanchion has been finally plumbed and levelled the space under the base plate shall be completely filled with cement grout. When this grout has hardened sufficiently the steel packings shall be removed by the specialist. Alternatively a centre plate packing 50 mm square may be provided and left in to aid the levelling operation.

8.24 Bedding of Steel Work

8.24.1 Bedding shall be carried out with portland cement grout, mortar or fine concrete. Grout shall be used for voids under 25 mm in thickness and it shall be just sufficiently fluid to flow and fill the voids completely.

8.24.2 For voids between 25 mm and 50 mm in thickness fluid Portland cement mortar of a strength not less than 1:2 shall be used. Fluidity shall be consistent with its ability to fill the voids completely. For voids in excess of 50mm thick semi-dry Portland cement mortar of a strength not less than 1:2 or fine concrete of a strength not less than 1:1:2 shall be thoroughly rammed into the voids until they are filled. Formwork shall be placed around the faces away from the end at which the ramming operations are being carried out in order to prevent the loss or lack of consolidation of the materials.

8.24.3 Before grouting the steelwork bases shall be supported by steel wedges and immediately prior to grouting the voids to be grouted shall wedges and immediately prior to grouting the voids to be grouted shall be thoroughly cleaned out. The operations shall not be carried out until the steelwork has been finally levelled and plumbed.

8.25 Particular Requirements

8.25.1 Design Loads for Structural Steelwork

8.25.2 The Contractor shall design all steelwork to allow for a live load of 0.60 KN/m².

8.25.3 Allowance to be made for all ceilings which are suspended from the steel frame.

8.25.4 Design wind speed to be 120 km/hr.

8.25.5 All calculations and drawings to be submitted to the Engineer for approval.

8.25.6 It should be noted that the approval of the Engineer does not absolve the Contractor from his responsibility with respect to his calculations and to any dimensional errors.

9. FLOOR, WALL AND CEILING FINISHES

9.1 Cement

9.1.1 The cement shall be as described in 'Concrete work'.

9.2 Water

9.2.1 Fresh water or MWSC water containing not more than 10 parts per million dissolved solids shall be used for all reinforced concrete work. It shall not contain vegetable matter, acid, sulphates, chlorides or other salts and other chemical impurities in such quantities as to cause efflorescence and may adversely affect the finishes and shall comply with BS 3148.

9.3 Sand

9.3.1 The sand is to be clean, sharp, river sand free from earth, loam, saline materials or other impurities and well graded from coarse to fine.

9.3.2 For use in plastering, sand is to comply with the requirements of BS1198 Table 1.

9.3.3 For use in beds, granolithic finishings, tile bedding and jointing, etc., sand is to comply with the requirements of BS 1199 Table 1.

9.4 Admixtures and Plasticisers

9.4.1 All additives and the like shall only be used when approved in writing by the Engineer and in strict accordance with the manufacturer's written instructions.

9.5 Colour Pigments

9.5.1 Colour pigments shall comply with the requirements of BS 1014, and are to

be lime proof and non fading.

9.6 Plasterboard

- 9.6.1 Plasterboard shall be self-finished gypsum wallboard, or gypsum lath or baseboard where to receive a skim coat, complying with requirements of BS 1230. (National Gypsum Company homepage: <http://www.nationalgypsum.com/>)

9.7 Tiles

- 9.7.1 Unglazed ceramic floor tiles and coved skirting are to comply with the requirements of BS 1286.
- 9.7.2 The glazed ceramic wall and floor tiles are to comply with the requirements of BS 1281.
- 9.7.3 Glass mosaic tiles to be selected by Engineer.
- 9.7.4 Natural stone tiles to be selected by Engineer.

9.8 Adhesives and Sealants

- 9.8.1 3-4mm high performance tropical grade thin flat bed water proof membrane adhesive by Feb, Bol or Fosrock or equivalent and approved - applied in accordance to manufacturer's written instructions. Specifically designed for the fixing of tiles in wet areas and provide a waterproof membrane to substrate.

9.9 Workmanship Generally

- 9.9.1 Workmanship shall conform to the recommendations of the appropriate Codes of Practice. The Contractor is responsible for the provision of all labour, scaffolding, materials, tools, plant, etc., required for the completion of the execution of the Works, to the full satisfaction of the Engineer.

9.10 Defective/Damaged Work

- 9.10.1 All defective or damaged work shall be cut out and patched as directed by the Engineer. All patched surfaces shall match the consistency and finish of the original surface and shall be level with adjoining surfaces.
- 9.10.2 Damaged or deteriorated materials and manufactured items shall not be used in the Works. Any materials or manufactured items damaged during and after bedding or setting in position shall be removed and replaced by and at the Contractor's expense.

9.11 Storage

- 9.11.1 All branded materials delivered to site are to be properly stored in a watertight shed on a dry floor, or in equivalent conditions to avoid

deterioration prior to use. Any materials which deteriorate or become damaged before use are to be removed from site and replaced at the Contractor's expense.

9.12 Preparation of Surfaces

- 9.12.1 Surfaces to receive plastering, beds and the like are to be dry brushed to remove all loose particles, dust, laitance, efflorescence and the like, any projecting fins on concrete surfaces shall be hacked off. All traces of mould oil shall be removed from concrete surfaces by scrubbing with water containing detergents and rinsing with fresh water.
- 9.12.2 Surfaces are to be wetted and re-wetted as required to equalise suction before the first coat of plaster or the like is applied. Particularly dense, hard concrete surfaces are to be wetted and re-wetted as required before bonding plaster is applied.
- 9.12.3 Where surfaces are out of line, they are to be brought to level by hacking or dubbing out in similar mix to the undercoat prior to commencement of finishings. Irregularities in surfaces to be plastered shall be filled with mortar (without lime) twenty four hours before plastering commences.
- 9.12.4 Joints in block work and the like shall be well raked out before re-plastering to form a good key. Smooth concrete surfaces to be plastered shall be treated with an approved proprietary bonding agent.
- 9.12.5 Plastering shall not be commenced until all mechanical and electrical services, conduits, pipes and fixtures have been installed.
- 9.12.6 The Contractor shall satisfy himself as to the suitability of all surfaces prior to the commencement of the application of the finishing material.

9.13 Plastering and Rendering

- 9.13.1 Internal plastering is to comply with BS 5492.
- 9.13.2 The plaster for use internally is to be composed of one part cement, and four parts of sand, and is to be applied in two coats to a the finished stated thickness.
- 9.13.3 The render for use externally is to be composed of one part cement and four parts of sand, and is to be applied to the finished stated thickness externally.
- 9.13.4 Plaster or render is to be mixed in clean buckets and gauge boxes. All tools are to be kept clean and fresh plaster or render is not to be contaminated with set plaster or render.
- 9.13.5 The ingredients for the plaster or render are to be mixed three times dry and three times while water is added. Alternatively mixing may be done by approved mechanical mixers, which are to be cleaned before use.

- 9.13.6 The working time permissible after the addition of water to the plaster or render mix is to be thirty minutes. Mixed plaster or render that has exceeded this limit is to be removed from the site and not retempered and used in the works.
- 9.13.7 The Contractor is to ensure that before plastering or rendering commences the junctions between differing base materials are reinforced with a strip of galvanised expanding metal lath secured at both edges. All angle beads and the like shall also have been fixed.
- 9.13.8 All surfaces to be plastered or rendered are to be sprayed with water, with is to be allowed to dry out before a key coat of cement slurry is applied.
- 9.13.9 All undercoats are to be scratched to form an adequate key for the next coat. The setting coat is not to be applied until the floating coat has been left in a moist condition for at least three days.
- 9.13.10 All Plastering shall be executed in a neat workmanlike manner and made good to wood frames, skirting, pipes, fittings and the like.
- 9.13.11 Plasterwork is to be finished with a smooth, trowelled face, free from blemishes and fit to receive decoration. Render is to be finished with a wood float. Any blown, cracked or otherwise damaged plaster or render shall be condemned by the Engineer and is to be hacked off and made good with quick setting plaster at the Contractor's expense.
- 9.13.12 Full use is to be made of grounds, rules and angle trowels to ensure that all wall faces finish plane and true to line in all direction and that all angles are straight, true and plumb. Prices for plastering and rendering are to ensure that work to walls and ceilings are effectively 'cut' at the joint so as to minimise damage due to movement.

9.14 Beds for Floor Tiling

- 9.14.1 Beds for floor tiling shall be composed of 1 part cement and 4 parts of sand by volume. Mixing, all as previously described.
- 9.14.2 Prices shall include surface preparation, temporary rules, laying to falls and cross falls as required by the room location, making good and the like.

9.15 Sand Cement Screed

- 9.15.1 Floor screeds are to compose of one part cement and three parts sand and are to be smooth and level. Final difference in levels in any part of the building shall not exceed 2 mm, otherwise the Contractor shall be required to apply an approved self levelling screed to finish the surface.
- 9.15.2 Where beds are to be laid direct on to a concrete sub-floor that has set, the surface of the sub-floor is to be thoroughly cleaned and prepared to ensure a good bond, the surface being chipped with a pick if necessary, brushed well

and washed out to remove all dust and dirt, and thoroughly soaked with water left on overnight. Surplus water is to be mopped up and immediately prior to laying the bed, the sub-floor is to be coated with a grout of neat cement wash well brushed on as the work proceeds. The grout must not be permitted to set before the bed is laid.

9.15.3 Alternatively the Contractor may use a bonding agent applied in conformity with the manufacturer's instructions.

9.15.4 Pipes, conduits and the like to be embedded in a screed or topping shall be securely fastened to the concrete subbase, then apply cement and sand haunch to the side of pipes/conduits and a layer of chicken wire mesh overlaid at least 200 mm wide at each side. When these operations have been completed the Contractor may commence the laying of screed/toppings.

9.15.5 The Contractor shall lay screeds or toppings in bay sizes as instructed by the Engineer including filling joints between bays as directed. Joints in the concrete subbase shall be continued through the screeds or toppings.

9.15.6 The screeds or toppings shall be finished to give the surface stated using either a hand trowel, mechanical power float or the like. All finishes shall be uniform, smooth and free from ridges, trowel marks and other blemishes. For a non-slip finish apply carborundum particles between successive trowelling operations to give a smooth surface.

9.15.7 The beds shall be protected from excessively rapid drying out by means of tarpaulins or polythene sheeting for a minimum of 7 days after laying.

9.15.8 Laying beds is preferably to be carried out when the building is fully protected from adverse weather, however, the Contractor is to protect all beds as necessary from damage by wet weather.

9.16 Wall Tiling

9.16.1 Glazed ceramic wall tiles shall comply with the requirements of BS1281.

9.16.2 The surfaces to which tiles are to be fixed are to be thoroughly dry before fixing commences and free from all defects. Any such defects are to be made good before work commences. Wall tiling shall be carried out in accordance with CP 212.

9.16.3 Tiles that are to be fixed to wall surface by bedding in an approved adhesive, extreme care being taken in the setting out, lining and levelling of tiles. All external angles are to be mitre jointed or rounded edged tiles as the location dictates. The adhesive is to be applied strictly in accordance with the manufacturer's instructions. The surface of the backing shall be scratched in an approved manner, when completely set, to form a key.

9.16.4 The agreement of the Engineer to the setting out of tiles is to be obtained

before commencing work and a sample room is to be set out for the Engineer's approval prior to continuing work on other rooms.

9.16.5 Shop drawings shall be prepared where patterns in the wall tiling are required.

9.16.6 Tiles shall be fixed with true horizontal and vertical joints of an even width of 1-2 mm to a true vertical plane.

9.16.7 Tiles adhesive shall be approved in writing by the Engineer prior to the commencement of this work.

9.16.8 Adequate time shall be allowed to enable complete setting of the tile bedding before joints are grouted. Grout of a plastic mix of neat cement, colour to Engineer's selection, shall be used in grouting up the joints. The whole of the tiled surface is to be thoroughly cleaned down on completion and left in perfect condition.

9.16.9 Any cut tiles are to be neatly and cleanly cut using an approved method and cut tiles are to be used only at internal corners or in other locations to be approved by the Engineer. All service points in wall tiling shall be of drilled holes if the tiles in which they are located are central to the tile.

9.17 Floor Tiling

9.17.1 Prior to commencing the floor tiling the Contractor shall satisfy himself that the surface on which the tiles are to be laid is satisfactory to receive the tiles. It is the responsibility of the Contractor to provide a satisfactory surface and or bedding and any remedial work necessary is to be carried out at the Contractor's expense.

9.17.2 Before laying commences the base is to be free from dust, loose material, grease, plaster, and the like.

9.17.3 Care is to be taken in cutting and fitting and the setting out of tiles and colour patterns are to be as shown on the drawings or as directed by the Engineer. Shop drawings are required where patterns in the floor tiling are required. Any adhesive on tile surface or

9.17.4 any other finished surface is to be completely cleaned off, The tiles shall be laid with true aligned joints of an even width of 1-2 mm and grouted up on completion.

9.17.5 The work shall be set out from the centre of rooms using whole tiles and working outwards. Rates are to include for the all cut margins and make up pieces at limits and boundaries.

9.17.6 The flatness of tiled or paved floors must be such that a two meter rule moved in all directions shows no bump or hollow of over 4 mm.

- 9.17.7 The Contractor is to store floor tiles in such a way that they are protected from moisture until laying. Ceramic floor tiles shall be laid in a manner as previously described in this section onto a cement and sand bed, with even joints of not wider than 2mm. Care being taken to adequately fill and remove all air pockets from beneath the tiles. The tiles are to be grouted with a tinted mortar mix to match the tiles, a minimum of twelve hours after completion of the tiling.
- 9.17.8 All floor tiling in wet area such as bathrooms, toilets, kitchen, washing area, balconies, mechanical rooms and the like above ground floor level shall be laid over a waterproof membrane on a sub base. Provide continuous skirting up walls. Floor tiling shall be laid to falls towards drainage outlet of respective rooms.
- 9.17.9 Protect floor tiling with slurry or like material on completion and clean off and prepare flooring to satisfaction of Engineer.

9.18 Light Glued Floor Coverings

9.18.1 Surface Preparation

- 9.18.1.1 The light glued floor coverings shall be laid on a screed to the thickness shown on the drawings. All screed materials shall conform to the requirements of previous clauses of this section. The screed thickness shall include taking out all irregularities in the floor slab and be finished true and level so that a 2 metre ruler laid on the floor shows no dip or bump of more than 3 mm. Prior to the installation of the floor covering a levelling screed shall be laid to ensure a perfectly smooth surface. The product shall be selected from a range that is compatible with the adhesive to be used. Products with a caseine or plaster base shall not be used.

9.18.2 Laying of Timber Strip Flooring

- 9.18.2.1 This work shall not commence until the levelness and surface of the levelling screed is approved in writing by the Engineer. Further preparatory work shall be at the Contractor's expense.
- 9.18.2.2 The adhesive used shall be that as specified by the tile/sheet manufacturer and applied in accordance with the written instructions. All surfaces to receive adhesive shall be clean and free from dirt to avoid poor adhesion and unevenness of finished surface. The flooring shall be laid by double gluing unless otherwise stated in the technical instructions. All joints shall be welded perfectly in line and all cutting and fitting at corners, junctions and the like shall be carried out in a workmanlike manner. Skirting tiles shall be fixed as detailed to room perimeters ensuring a neat joint at the junction with the

flooring. Excess adhesive shall be carefully removed to ensure no damage to the flooring.

- 9.18.2.3 All sections of the flooring that show poor adhesion, swelling, bumps and hollows greater than approved by the Engineer, inaccurate joint alignment, open joints, poor workmanship, cutting and the like shall be removed and redone at the Contractor's expense.

9.18.3 Laying of Textile Flooring

- 9.18.3.1 The surface shall be prepared as for the plastic flooring and these works shall be carried out in accordance with BS 5325 by experienced operatives. This work shall not commence until the building is watertight and all wet trades including painting and the mechanical and electrical works are completed.

9.19 Suspended Ceilings

9.19.1 General

- 9.19.1.1 The Contractor shall be responsible for the co-ordination of the service and suspended ceilings, including checking the ceiling heights and setting to module, which shall be to the exact locations required by the Engineer, who shall confirm and approve the setting out and location of all fittings, luminaires, switches, smoke detectors, security alarms and detectors, air conditioning grilles and controls and the like. Ceilings shall be installed by specialists. They shall be capable of outstanding normal air pressure and suction forces action both below the ceiling and within the ceiling void.
- 9.19.1.2 The Contractor shall prepare, and submit for approval, fully dimensioned working drawing prepared from the general working drawings of the Engineer and from a site survey. These drawing shall coordinate the service and ceiling installation. Setting out points common to all trades including service shall be established early in the manner described and shown on the working drawings.
- 9.19.1.3 Under no circumstances shall work of other sections be concealed by ceilings until same has been inspected and approved by the Engineer.
- 9.19.1.4 Finished ceiling heights shall be rigorously respected; they shall be measured from the finished floor levels.
- 9.19.1.5 The ceilings shall be left perfectly flat and shall not show a

deviation of more than 3 mm from a 3 metre straight edge. The Contractor shall take all possible precautions to eliminate any defects.

- 9.19.1.6 Price shall include for cutting and fitting ceilings around obstacles and neatly finishing the edges of the work.
- 9.19.1.7 Proprietary suspended ceiling system shall be installed in strict accordance with the manufacturer's instructions, by workmen skilled in this work in a rigid and secure manner so that the final surface is free of any waves, buckles or sap.
- 9.19.1.8 Tiles and ceiling forming a grid or pattern shall be set out on the axis of the room in both directions.
- 9.19.1.9 Suspended ceilings shall not be erected until the windows have been glazed, the building closed in, the plasterwork dried out, all wet work completed and the building suitably air conditioned; relative humidity must not exceed 70% and the temperature must be maintained within the range 15-30°C
- 9.19.1.10 The design of and dimensional tolerances set by the manufacturer for accessory items such as formed wire hangers, spring spacer clips, tile retainers, and spacer bars shall be such as to assure satisfactory performance of their intended function in the suspension system. Failure attributable to such accessories to control alignment, prevent undesirable rotation or other unsatisfactory performance which results in unfavourable appearance will be cause for their rejection.
- 9.19.1.11 General installation procedures shall be as follows:
 - ◆ The area to receive treatment shall be dry and be satisfactorily closed against excessive traffic and be protected against weather before work is started.
 - ◆ Installation shall be in strict accordance with manufacturer's specifications except as modified by this Specification.
 - ◆ Install units in a true and even plane, in straight line course laid out symmetrically about centre lines of ceiling or panel, continuing pattern, through wall openings or as indicated. Border tile shall not be less than 15 cm wide.
 - ◆ Fit border units neatly against vertical surfaces.
 - ◆ Seal joints in units around pipes, ducts, and electrical outlets with acoustical sealant.
 - ◆ Carefully coordinate and fit units to grilles, lighting fixtures and other related items of work. In determining spacing and locations of hangers for main runners and carrying channels, take into consideration the weight of grilles, fixtures, etc. that are to be installed in conjunction with acoustic ceilings.

9.20 Roads and Paving

9.20.1 Materials

9.20.1.1 Interlocking paving tiles shall be as manufactured by Pasco or equal and approved, 60 mm thick for walkways and 80 mm thick for driveway and parking areas, colour, pattern and type to be approved by Engineer.

9.20.1.2 The sand used in this work shall be obtained from approved sources and shall comply with the requirements of BS 882 Zone II.

9.20.2 Construction

9.20.2.1 Tiles shall be laid on a 40 mm thick black sand bed. On completion all joints are to be filled with sand. The underlying sub-base course thickness shall be as described and be imported material compacted to 95% maximum dry density and attaining a CBR value of more than 60. The sub-grade shall be well compacted and shall attain a CBR value of more than 25.

9.20.3 Kerbstones

9.20.3.1 Precast concrete kerbstones shall comply to BS 340, Figure 6 for use in roads and paving. The kerbstones shall bedded and haunched on mass concrete using sulphate resisting cement.

10. PAINTING & DECORATION

10.1 General

10.1.1 The painting materials shall be obtained from an approved manufacturer and shall be supplied ready mixed in the manufacturer's sealed and branded containers. Each container shall bear the maker's brand name, identification of contents and directions for its proper use. All material must be thoroughly stirred before use.

10.1.2 All sealers, primers, undercoats and thinners shall be the products recommended by the manufacturers of paint used for the finishing coat.

10.1.3 Unless otherwise indicated on the Drawings colours shall be selected by the Architect.

10.2 Materials

10.2.1 Rust Inhibitors

10.2.1.1 Rust inhibitors shall be of approved manufacture.

10.2.2 Knotting

10.2.2.1 Knotting shall comply with BS 1336.

10.2.3 Stopping

10.2.3.1 Stopping for woodwork to receive clear finish shall be tinted to

match surrounding woodwork, to approval.

10.2.3.2 Stopping for internal woodwork, plywood, hardboard, and fibreboard shall be linseed oil putty to BS 544. tinted to match the colour of the undercoat.

10.2.3.3 Stopping for external woodwork shall be white lead paste and gold size well mixed.

10.2.4 Thinners

10.2.4.1 Thinners shall be approved turpentine or white spirit to B.S. 245.

10.2.5 Stain

10.2.5.1 Stain for woodwork shall be an approved brand of oil stain complying with B.S. 1215.

10.2.6 Polyurethane Lacquer

10.2.6.1 Polyurethane lacquer for woodwork shall be of an approved manufacture.

10.2.7 Varnish

10.2.7.1 Varnish for interior woodwork shall be an approved brand, oil varnish. Varnish shall form a hard flexible transparent and quick drying film.

10.2.8 Linseed Oil

10.2.8.1 Linseed oil for woodwork shall be refined linseed oil to comply with B.S. 246.

10.2.9 Priming Paints

10.2.9.1 Priming paints shall be the primer recommended by the manufacturer of the finishing paint or:

- ◆ For woodwork -lead-based or priming paint to comply with B.S. 2521 and 2523.
- ◆ For steel work-red oxide priming paint to comply with B.S. 2524.
- ◆ For galvanized, zinc or aluminium work- grey zinc chromate priming paint.
- ◆ For concrete, blockwork, plaster, plasterboard and the like- alkali priming paint.

10.2.10 Undercoating

10.2.10.1 Undercoating shall be:

- ◆ Zinc oxide based undercoating paint.
- ◆ White lead based undercoating paint in accordance with B.S. 2525-7. Colours shall approximately match the finishing paint.

- ◆ Synthetic alkyd based undercoating in accordance with the recommendations of the paint manufacturer.

10.2.11 Finishing Paints

- 10.2.11.1 Finishing paints shall be as otherwise specified.

10.3 Workmanship

10.3.1 General

- 10.3.1.1 The Contractor shall carry out all tests necessary for determining the colours and shades of the finishes and the appropriate methods of application. Sample panels shall be completed in accordance with Architect's instructions.
- 10.3.1.2 All work shall be performed in accordance with the manufacturer's written instructions.
- 10.3.1.3 Before application of any paint or finish all surfaces shall be cleaned, dried and prepared as specified hereinafter, all to the Architect's approval, no work shall commence until this approval is given in writing to the Contractor.
- 10.3.1.4 The Contractor shall coordinate work to ensure that factory primed items are primed or painted as required in the Specifications.
- 10.3.1.5 All metal fittings such as hardware and fastenings, etc., not required to be painted shall first be fitted and then removed before the preparatory processes are commenced. When all painting is completed the fitting shall be cleaned and refixed in position.
- 10.3.1.6 Before painting floors must be washed and every possible precaution shall be taken to keep down dust before and during the painting processes. No paint shall be applied to surfaces structurally or superficially damp and all surfaces must be ascertained to be free from condensation, efflorescence, etc., before the application of each coat.
- 10.3.1.7 No exterior or exposed painting shall be carried out under adverse weather conditions such as rain , extreme humidity, dust storms, high temperature of surface etc.
- 10.3.1.8 All coats of paint must be thoroughly dry before subsequent coats are applied, and rubbed down with fine waterproof abrasive where necessary.
- 10.3.1.9 All coating shall be well applied, leaving no sags, laps, brushes or other defects. Each coat must thoroughly dry before next coat is applied. All work must be carefully cut into a true line and left smooth and clean.

- 10.3.1.10 Details of mixing and application shall be in accordance with the Specifications of the manufacturer concerned and to the approval of the Architect. The mixing of paint, etc., of different brands before or during application will not be permitted. No dilution of painting materials shall be allowed except strictly as detailed by the manufacturers and as approved by the Architect.
- 10.3.1.11 On surfaces which are not accessible to paint brushes or rollers paint shall be applied by spraying or with sheep skin daubers. All surfaces to be painted shall be thoroughly covered with paint. Method of paint applications shall be approved by the Architect prior to the commencement of the work.
- 10.3.1.12 Brushes, pails, kettles and all other tools and equipment used in carrying out the work shall be maintained in good working order, and shall be clean and free from foreign matter. They shall be thoroughly cleaned before being used for different types or classes of materials.
- 10.3.1.13 The Contractor will be required to repaint, at his own expense any work on which the paint is found to be incorrectly applied. The Contractor shall be responsible for protecting from damage the paint work and all other work during and after
- 10.3.1.14 operations including the provision of all necessary dust sheets, covers, etc. All paints dropping shall be cleaned up as the work proceeds.
- 10.3.1.15 All loose and defective paint shall be removed from previously painted surfaces before re-painting. All burning off must be done by skilled workmen. The blow-lamp must not be used on surfaces adjoining glass. Damage to adjacent surfaces shall be made good at the Contractor's expense.
- 10.3.1.16 Prior to hand over the Contractor shall carry out all remedial painting work due to damage caused by others, adjustment and easing of joinery and metal work testing and commissioning of service installations and the like all as instructed by the Architect. On completion, leave Works clean and tidy to the Architect's approval.

10.3.2 Painting to Concrete, Block or Plaster

- 10.3.2.1 Concrete, block work and plaster surfaces to be painted or decorated shall have all cracks cut out and made good to the satisfaction of the Architect.
- 10.3.2.2 Plasterboard surfaces shall have taped joints and the surface puttied to the satisfaction of the Architect. The surfaces shall be completely dry and shall be brushed free of impurities immediately prior to the commencement of the painting work.
- 10.3.2.3 Efflorescence shall be completely removed by rubbing down

with dry coarse cloths followed by wiping down with damp cloths and allowed to dry. All surfaces shall be rubbed down with fine glass paper and brushed free of dust before applying any form of decoration.

- 10.3.2.4 Concrete block work and plastered surfaces which are to receive paint shall be given one thin coat of oil putty and allowed to dry for at least two days. The surfaces shall then be rubbed down with fine glass paper and given a second thin coat of oil putty and when completely set shall be rubbed down again with fine glass paper before applying the painting system.
- 10.3.2.5 Emulsion paint shall be applied by brush or roller and shall consist of primer and two full coats of paint.
- 10.3.2.6 Texture paint shall be uniformly applied at a rate of not less than 4m² per litre by overlapping, crisscross rollers or spray in accordance with the manufacturer's instructions. Where finished surfaces are described as having smooth texture finish, the overall thickness of the applied finish shall be less than 1.5 mm. Where finished surfaces are described as having rough texture finish, the overall thickness of the applied finish shall be not less than 2 mm. Finished surface shall be uniform in sheen colour and texture, free from runs, sags, crawls or other defects.
- 10.3.2.7 Oil paint shall be applied by brush or roller and shall consist of a priming coat, two undercoats and one finishing coat of paint.
- 10.3.2.8 Fire resistant paint shall be applied in three coats over a primer all in strict accordance with the manufacturer's instructions.

10.3.3 Lacquer to Woodwork

- 10.3.3.1 Woodwork to lacquered shall be cleaned of impurities.
- 10.3.3.2 Knots shall be treated with two coats of knotting.
- 10.3.3.3 Where shown on the Drawings or required by the Architect the wood shall be stained with a water or spirit stain to the approval of the Architect.
- 10.3.3.4 The coats of lacquer shall be applied on joinery by brush or spray, either in the joinery shop or on Site as directed by the Architect.

10.3.4 Oil Stain Finish to Woodwork

- 10.3.4.1 The stain finish to woodwork shall be an approved manufacturer's oil stain system applied strictly in accordance with the manufacturer's instructions.
- 10.3.4.2 All surfaces are to be thoroughly dry and cleaned and sanded down and all nail holes or similar defects shall be filled and levelled up with approved stopping.

- 10.3.4.3 The finish shall be applied in two coats. The first coat shall be pigmented stain wax brush applied. The surface shall be allowed to dry for 2 -10 minutes and then rubbed with a cloth in a rotary motion to remove excess stain and produce an even surface.
- 10.3.4.4 The first coat shall be allowed to dry completely before application of the second coat.
- 10.3.4.5 The second coat shall be natural (clear) stain wax, buffed.
- 10.3.4.6 The Architect shall select the stain colour and the Contractor shall allow for preparing sample panels for approval and these sample panels will provide the standard for the work.

10.3.5 Varnishing

- 10.3.5.1 All surfaces to be varnished shall be thoroughly dry and cleaned and sanded down and all nail holes or similar defects shall be filled and levelled up with approved hard stopping. Sanding shall follow the line of the grain. Knots shall be treated with two coats of knotting.
- 10.3.5.2 Two or three coats of clear varnish shall be applied as recommended by the manufacturer of the varnish or as directed by the Architect.

10.3.6 Painting to Woodwork

- 10.3.6.1 Woodwork to be painted shall be cleaned of impurities.
- 10.3.6.2 Knots shall be treated with two coats of knotting.
- 10.3.6.3 Priming paint shall be applied by brush. Two coats shall be applied to end grain. Priming paint shall be applied on Site after the Architect has approved the joinery and before it is fixed.
- 10.3.6.4 When the priming paint is dry, all cracks, holes, open joints and the like shall be filled with stopping and rubbed down with fine flass paper.
- 10.3.6.5 Two undercoats and one finishing coat of paint shall be applied by brush.
- 10.3.6.6 The priming paint and undercoats shall be lightly rubbed down with glass paper to remove blemishes, and all dust removed before the application of subsequent coats.

10.3.7 Painting to Metalwork

- 10.3.7.1 Steelwork delivered to the Site unprimed shall be cleaned of impurities, scrapped and wire brushed to remove rust and painted with one coat of priming paint applied by brush.
- 10.3.7.2 Steelwork delivered to Site primed shall be cleaned of

impurities and damage to the priming paint and made good with priming paint.

10.3.7.3 Galvanized metalwork to be painted shall be cleaned of impurities. Where rusting has occurred the rust shall be removed by wire brushing and made good with an approved rust inhibitor. The surfaces shall be coated with a mordant solution, washed with clean water and painted with two coats of priming paint applied by brush.

10.3.7.4 Metal which is concealed shall be prepared and primed as above and shall be painted with two priming coats and one finishing coat of paint applied by brush.

11. HYDRAULICS AND DRAINAGE

11.1 Plumbing

11.1.1 General

- 11.1.1.1 The materials used and workmanship shall be of highest quality and grade unless otherwise specified shall conform to the latest specifications of British standards and codes of practice “ water supply “sanitary. Pipe work “building drainage “ surface water and sub- soil drainage” and applicable to details and work indicated on the drawing and bill of quantities. In case of any discrepancy / ambiguity the decision of the Engineers shall be final, and the Contractor will act and perform accordingly.
- 11.1.1.2 The work shall be executed strictly in accordance with the rules and regulations set by the relevant Local Authority of the Maldives.
- 11.1.1.3 The Contractor shall be responsible for obtaining the necessary approvals and test certificates from the concerned departments of Maldives.
- 11.1.1.4 Plumbing work shall be carried out by licensed plumbers and shall produce the copy of the license before executing the work, to be approved by the Engineer.
- 11.1.1.5 Any damage done by the Contractor to any existing work during the course of execution of his work, shall be made good by him at his own cost. Failing which it shall be get done by the Engineers at Contractor’s risk and cost.
- 11.1.1.6 The Contractor shall be responsible to connect the drainage pipe to the mains and to obtain the necessary approvals and certificates from the relevant authorities of the Maldives.
- 11.1.1.7 All connections to mains and meter installation shall be arranged by the Contractor and payment of fees thereof, if any, shall also be made by the Contractor.
- 11.1.1.8 The Contractor shall be responsible for the watch and ward of all fittings until the works is fully completed and handed over to the owner.
- 11.1.1.9 The levels, measurements and other information concerning the existing site as shown on the drawings or as described are supposed to be correct. The Contractor shall, however, verify them by himself and no extra claim whatsoever shall be entertained on account of the errors or omissions in such matters or on account of the descriptions turning out to be different from what was expected.

- 11.1.1.10 The Engineer shall instruct the Contractor to purchase and use such materials of particular make or from particular source as may in his opinion be necessary for proper and reasonable compliance with the specification and execution of the works.
- 11.1.1.11 After all plumbing fixtures and equipment have been set ready for use, and before the Contractor leaves the job, he shall thoroughly clean all fixtures installed by him, removing all plaster, stickers, rust stains and other foreign matter of discolouration on fixtures, leaving every part in acceptable condition and ready for use to the satisfaction of the Engineers.

11.1.2 Drawings and Information Required

- 11.1.2.1 The Contractor shall submit shop drawing for the entire installation including installation details for all items required or asked for approval of the Engineer.
- 11.1.2.2 Approved by the Engineer of shop drawing for any material, apparatus, devices and layout, shall not relieve the Contractor from the responsibility of furnishing same of proper dimension, size, quantity and all performance characteristic to efficiently perform the requirements and intent of the contract documents. Such approval shall not relieve the Contractor from responsibility for errors of any sort in the shop drawing.
- 11.1.2.3 If the shop drawings deviate from the contract documents the Contractor shall advise the Engineers of the deviations in writing accompanying the shop drawings including the reasons for the deviations. At the start of the project the Contractor shall periodically and thereafter submit to the Engineers list of all shop drawings which will be submitted in the course of the project. The list shall show the disposition of each item including date of submission and approval etc. The list shall be kept up to date through the entire course of construction.

11.1.3 Record Drawing

- 11.1.3.1 During construction the Contractor shall keep an accurate record of all deviations between the work as shown on the contract drawings and that which is actually installed.
- 11.1.3.2 The Contractor shall secure from the Engineers after approval of his shop drawing a complete set of drawing and note changes thereon in ink.
- 11.1.3.3 The Contractor shall make a complete record of all changes and revisions in the original design which exist in the completed work.
- 11.1.3.4 The cost of furnishing above prints and preparing these for record “ shall be deemed to be include in the tendered cost and

its effects spread over other items of work, and as such item shall not be a subject to payment". When all revisions showing the work is finally installed the corrected Original Transparencies shall be submitted to the Engineers before final payment for the completed work will be made.

11.1.4 Operating and Maintenance Instructions

- 11.1.4.1 Three sets of operating and maintenance instruction covering completely the operation and maintenance of all plumbing equipment, controls, heaters, pumps and the like shall be furnished to the owner, by the Contractor.

11.1.5 Tests

- 11.1.5.1 The entire system of drains, waste and vent piping inside and outside the building shall be tested by the Contractor under a water test, which shall include the entire system from the lowest point to the highest pipes above the roof.
- 11.1.5.2 The water test shall be made in accordance with all local requirements. Every portion of the system shall be tested to a hydrostatic pressure equivalent to latest 15 feet head of water. After filling, the Contractor shall shut off water supply and shall allow it to stand 2 hours under test during which time there shall be no loss or leakage.
- 11.1.5.3 The Contractor shall furnish and pay for device, material supplies, labour and power require for all tests. All tests shall be made in the presence and to the satisfaction of Engineer.
- 11.1.5.4 Defects disclosed by the test shall be repaired or if required by the Engineer defective work shall be replaced with new work without any extra charge to the owner. Test shall be operated as directed until the work is proved satisfactory.
- 11.1.5.5 Fixture shall be tested for soundness, stability of support and satisfactory operation.
- 11.1.5.6 The Contractor shall notify the Engineer at least one week in advance of making the required test, so that arrangements may be made for their presence to witness the test.
- 11.1.5.7 Equipment shall be tested in service and the Contractor shall demonstrate that the equipment performs the work intended for it and that it complies with the requirement of these specifications for such equipment, to the satisfaction of Engineers.
- 11.1.5.8 The rates shall include for all costs associated with tests.
- 11.1.5.9 Timely notice shall be given by the Contractor to the Engineer of the hour of tests.

11.2 Work in Common Piping

11.2.1 Material

- 11.2.1.1 Piping and fitting material shall be U.P.V.C, Hard Impact U.P.V.C. or High Temperature U.P.V.C. and approved by the Engineer.
- 11.2.1.2 Piping material shall comply with requirements of Maldives Water Supply and Sewerage Authority and other relevant authorities and Engineers.
- 11.2.1.3 Materials for the piping and service requirements shall basically conform to the service pressures encountered.

11.2.2 Providing Drawings and Manuals

- 11.2.2.1 The Contractor shall submit one set of originals and further two copies of layout drawings to the Engineer after completion of the Works. These drawings must give the following information:
 - (a) Run of all piping and diameter on all floors and the vertical stacks.
 - (b) Location and sizes of all control valves, access panels and other equipment.
 - (c) IL of all manholes including IL at our files.
- 11.2.2.2 The Engineer shall issue the Certificate of Completion only after the submission of the As Built Drawings by the Contractor.
- 11.2.2.3 The Contractor shall submit to the Engineer for approval, samples, shop drawings, manufacturer's drawings, equipment characteristics and capacity data etc. of all equipment, accessories devices etc. that he proposes to use in the installation.

11.2.3 Samples

- 11.2.3.1 The Contractor shall provide samples of all sanitary fittings, pipes and specials, man-hole cover and frames, gratings and water supply pipes and fittings etc., and shall be deposited with the Engineer (which will be returned to the Contractor at the completion of the Works) and shall obtain approval from the Engineer before using in the Works. Any material rejected by the Engineer shall be removed from the site within 24 hours of rejection.

11.2.4 Drawings

- 11.2.4.1 The works shall be done in conformity with the plans and within the requirements of the general Architectural, electrical and structural plans. This work shall be properly coordinated with the work of the other trades. Hangers and sleeves shall be furnished in time for their installation as other work proceeds.

- 11.2.4.2 The plumbing drawings are diagrammatic, but shall be followed as closely as actual construction and work permits. All deviations from drawings required to conform to the building construction shall be made by the Contractor at his own expense.
- 11.2.4.3 The Architectural drawings shall take precedence over the plumbing drawings as to all dimensions.
- 11.2.4.4 Large size details shall take precedence over small size drawings. The special dimensions in the specifications or schedule of quantities or instructions of the Engineer shall supersede the drawings. The Contractor shall verify all dimensions at site.
- 11.2.4.5 The recommend position of the fittings, fixtures, control valves, tanks etc. as shown on the drawings will be adhered to as far as practicable.
- 11.2.4.6 Should there be any discrepancy due to incomplete description ambiguity or omission in the drawings and other documents, whether original or supplementary, forming the contract, either found on completion or during the course of the installations work, the Contractor shall immediately, on discovering the same, draw the attention of the Engineers and the Engineers decision is final and binding on the Contractor.

11.2.5 Existing pipes

- 11.2.5.1 The site shall be examined for field drains and those, when found, shall be either entirely removed or diverted, trenches filled with dry earth in 200mm to 300mm layers and consolidated as directed by the Engineer.

11.2.6 Spare Parts

- 11.2.6.1 Necessary spare parts of the plumbing equipment for the one (1) year operation shall be supplied by the Contractor.

11.2.7 Excavation

- 11.2.7.1 All excavations shall be steel/timber to the satisfaction of the Engineer and the type of steel/timber shall be suitable to the kind of earth encountered. Fixing of timber and removal after completion of work shall be done as directed by the Engineer.
- 11.2.7.2 Should any water accumulated in the trenches, headings or other excavation, the Contractor shall do such work as may be necessary to drain away the accumulated water and shall install pumps as may be required to keep the excavation and trenches dry. The Contractor shall ensure that the flow water in trenches or excavation does not injure or remove cement or aggregate of any concrete that has not set. No subsoil water shall be discharged into open drains or sewer at the site.

- 11.2.7.3 In refilling trenches after excavation this should be done in layers of 150mm after consolidating each layer. Special care shall be to see that the earth is packed uniformly and no injury to the pipe.
- 11.2.7.4 Rates for excavation should include for backfilling in consolidated layers where necessary and as directed by the Engineer.

11.2.8 Piping

- 11.2.8.1 The Contractor shall, as soon as possible after the award of the contract, prepare and submit to the Engineer for approval, working drawings showing exact locations and pipe runs for all pipework, the layout and setting up of equipment and the connection of piping to the equipment. Such drawings shall include details and methods of supports, anchors and sleeves etc.
- 11.2.8.2 Pipe runs shown in the drawings are approximate and intended to indicate the general run and locations only. The exact locations of all pipework shall be determined on Site.
- 11.2.8.3 All pipes, fittings etc. shall be kept closed against moisture and foreign matters when stored at site and during installation.
- 11.2.8.4 All pipes shall be fixed clear of one another and be so arranged as to provide easy access for maintenance and repair.
- 11.2.8.5 All plumbing work shall be carried out by qualified plumbers in accordance with the British Code of Practice and Regulations and requirements of related Authorities.
- 11.2.8.6 Materials for the piping and service requirements shall basically conform to the service pressures encountered.
- 11.2.8.7 Each part of the installation of the plumbing work shall be completed in all details as shown in the drawings or as specified and provided with all necessary control valves, etc. that will be necessary for their satisfactory operation.
- 11.2.8.8 All piping shall be run plumb, and straight and parallel to walls, except drain line which shall pitch as per the slopes mentioned in drawings in the direction of flow or as per the Engineers instruction.
- 11.2.8.9 Pockets, unnecessary traps, turns and off-sets shall be avoided. When traps or pockets are unavoidable they shall be valved drains.
- 11.2.8.10 Piping installed on the concrete slab shall be firmly fixed or anchored to the floor with packing to prevent damage to pipes. Pipes shall not be bent with bender where cross with other pipe or change to upward.
- 11.2.8.11 Where pipes are to be laid directly in the ground, bed shall be

sufficiently compacted, necessary protection for piping shall be taken.

- 11.2.8.12 Backfill shall be done after the approval of the Engineer in such a manner not to damage the pipe line and shall be restored to the original stage.
- 11.2.8.13 Where pipes penetrate through waterproof part or fire partition or fire wall, pipe sleeves shall be provided and clearance between pipe sleeve and pipe shall be filled with caulking material approved by the Engineer.
- 11.2.8.14 Pipes, fittings, valves and accessories shall be thoroughly cleaned, both internally and externally before installation and shall be cleaned before putting into service.
- 11.2.8.15 Plumbing work shall be completed in accordance with the details shown on the Drawings or as specified and provided with all necessary control valves, etc. that will be necessary for their satisfactory operation.
- 11.2.8.16 All pipes shall be cut square and true to the pipe axis by means of suitable tools without reducing pipe diameter and cut ends shall be finished smooth. Before making connections, chips, dirt and other foreign matter shall be removed from inside interior of each pipe. Fixing of hangars and embedding of pipe sleeves shall be carried out without delay along with the progress of the work where required.
- 11.2.8.17 Pipe connections shall be made by means of appropriate socket fitting etc. Jointing shall be generally by means of solvent cement according to manufacturer's instructions
- 11.2.8.18 Vertical pipe shall be braced at more than 2 point in every storey

11.3 Water Supply Work

11.3.1 Materials

- 11.3.1.1 Pipes, joints and fittings for water supply work shall be high pressure U.P.V.C. (as per the pressure ratings mentioned in BOQs, drawings and Plumbing specifications) Materials and workmanship shall comply with the local water supply authority requirements.

11.3.2 Water pump

- 11.3.2.1 Fresh water pump system shall be supplied & installed by the Contractor. All the pump specialisation shall be submitted to the Engineer for approval. Provided pump head need to be verified by the contractor with actual pipe paths and available pressure levels of the MWSC city water supply.

11.3.3 Spacing of supports

11.3.3.1 Support spacing for P.V.C pipes shall be as follows:

Nominal Diameter	Up to 40	More than 50
Space (m)	1.2	1.5

As per the Plumbing specifications given.

11.4 Drainage Work

11.4.1 General

- 11.4.1.1 High Pressure P.V.C pipe and fittings (as per the pressure ratings mentioned in BOQs, drawings and Plumbing specifications) shall be used for all drainage work including vent pipes.
- 11.4.1.2 Joints shall be made by the cold-jointing method, and the pipe interior shall have not offset at the joint interfering with the flow. Joint adhesive shall be good quality and shall not be affected by heat and shock.
- 11.4.1.3 Where horizontal drain branch joints the main, such branch shall be connected to the main in a substantially horizontal position and at an acute angle of not more than 45 degree to the main in all cases.

11.4.2 Vent stack pipes

- 11.4.2.1 Vent pipe shall be vertically branched out upward from a horizontal drain branch pipe or other appropriate point. Horizontal branching of the vent pipe shall be done on approval of the Engineer.
- 11.4.2.2 Where vent pipes on each floor are to be connected to the vent stack, all connections shall be made at least 400mm above the respective overflow edges of fixture on that floor.
- 11.4.2.3 The provision of the preceding item shall also apply to the connection of vent stack vent pipe.
- 11.4.2.4 Vent stack shall be connected to the waste stack or soil stack at the lowest part to stack pipe.
- 11.4.2.5 Where vent pipe is to be connected to the horizontal drainpipe, such angle shall be more than 45 degree to upward.
- 11.4.2.6 Vent stack shall be extended 600 mm from the top of the roof or parapet and top of pipe shall be covered with vent cap.

11.4.3 Spacing of support

- 11.4.3.1 Spacing for support shall conform to the section of water supply work item of spacing.

11.4.4 Laying of pipes

- 11.4.4.1 The pipes shall be laid to proper lines and levels as shown in the plans and directed by the Engineer, as the main is laid, the front pipes in the trench shall always be closed with a plug either of iron or wood and security fastened. The plug shall not be removed except when pipe laying is resumed or for purposes of testing.

11.5 Sewer Mains

- 11.5.1.1 All mains shall be laid on a good solid, bottom to prevent subsidence and consequent fracture. Mains running under buildings, if unavoidable, shall be completely surrounded by 150mm of concrete. In case of mains passing through a well, the weight of the latter shall be carried by a lintel or a suitable relieving arches. All rising mains shall be properly plugged to all wall brackets at regular intervals as given in the drawings. All mains shall be concealed inside wall as far as possible except for vertical sewer mains, cleaning doors shall be provided in the walls whenever necessary and as directed by the Engineer.
- 11.5.1.2 After the cement has had time to set, the pipes shall be tested in length between manholes in the following manner.
- 11.5.1.3 In the lowest manhole/intercepting trap as the case may be, a plug shall be inserted in the pipe. The disc in the pipe at the upper manhole shall be fitted with a filling pipe with a right angle bend and an air cock. The pipeline shall then be filled with water by means of the pipe connection on the upper disc. The air cock on the upper disc shall be kept open while the pipeline is being filled to permit the escape of air. When the pipes are filled with water and air excluded, the air cock shall be shut and the water shall be poured into conical filler, attached to the filling pipe until the water remains in the filter. The filling pipe shall then be raised and fastened so that the height of surface of the water in the filler above the invert of the pipe is 1828 mm which will be usual test pressure for s.w pipes. If the water level does not fall more than 16mm (12mm) in a length of 91.4 metre the test may be considered satisfactory. The Contractor shall good all defective work at his own expense.

11.6 P.V.C Pipes

- 11.6.1.1 Manufacturer's instruction should be followed, pipes to be used for water mains shall where specified have integral rubber ring joints when solvent cement joints are specified, a sufficient number of expansion/contraction joints shall be incorporated in the length of mains to allow for variation of temperature to the recommendation of the pipe manufacturers.

- 11.6.1.2 These pipes shall be effectively protected from the direct rays of sun immediately after they are laid and until permission is given for the trenches to be refilled by the Engineer. Subject to such permission being obtained, trenches shall be refilled without delay. Final connection at a fixed point shall be deemed unto the majority of the length of the pipe line has been covered by backfill in order to reduce the effect of expansion and contraction caused by temperature variations.

11.7 Support for U.P.V.C Pipes

- 11.7.1.1 When U.P.V.C pipelines incorporate metal valves or other heavy fittings, it is essential to support the valves directly rather than allowing their weight to be carried by the U.P.V.C. pipe and support shall be placed on either side of the fittings mentioned above. Moulded plastic fitting also should be supported.
- 11.7.1.2 Maximum allowable horizontal support distance for U.P.V.C. pipes are given below.

Nominal bore	12 mm (1/2")	18 mm (3/8")	25 mm (1")	32 mm (1 1/4")	38 mm (1 1/2")	50 mm (2")	75 mm (3")	100 mm (4")
Support distance	533 mm (1'9")	616 mm (2'0")	686 mm (2'3")	764m (2'6")	840 mm (2'9")	915 mm (3'0")	1220 mm (4'0")	1290 mm (4'6")

- 11.7.1.3 For vertical installation supports, distances shall be doubled.

11.8 Valves and Fittings

11.8.1 Sewer Pipe Fittings

- 11.8.1.1 All 'P', 'S', 'I' junctions bends etc. required shall be furnished and set without extra charge and shall confirm to the pipe specifications as to quality.

11.8.2 Air Valves

- 11.8.2.1 These valves to be fitted as per drawings and Bill of Quantities shall be tested and accompanied by a certificate of efficiency. The floating ball in the valve shall be suitable metal or vulcanite or rubber specially manufactured for tropical conditions.

11.8.3 Scour Washout Valve

- 11.8.3.1 These shall be provided at portions shown in place and shall contain in one unit a flanged scour valve with short connection

pieces, cast iron bend and T pieces for connection to main pipe. The rate shall also provide for short length of straight pipe to a convenient as per details complete with covers and surface boxes.

11.8.4 Foot Valves And Strainers

- 11.8.4.1 Foot valve and strainers should be of reputable manufacture approved by the Engineer and shall be fitted with flushing lever attachment where specified.

11.8.5 Pressure Reducers

- 11.8.5.1 Pressure reducing valves shall be of the equilibrium type of approved manufacture and capable of reducing the pressure to the valve required as per plan and Bill of Quantities.

11.8.6 Water Meter

- 11.8.6.1 This shall be provided if required by MWSC as per their specification and approval.

11.8.7 Equilibrium Ball Valves

- 11.8.7.1 These should be of reputable manufacture approved by the Engineer and be of the angle pattern with gunmetal valve seats guide bush, copper float with wrought iron lever and links with bronze pins.

11.9 Fitting and Fixture Quality

- 11.9.1 All sanitary pipes, gullies, water closets/bidets, squatting basins, sinks bathtubs etc., to be of approved design and to be obtained from approved manufacture and to be of the best stoneware glazed inside and outside, with burnt hard and sound, free from flaws, blisters, cracks and other imperfections and best quality commonly called 'firsts'. Rates should include for all bends, junctions, traps, specials, cleaning, painting, fixing clear of wall etc., complete as specified as per bill of quantities.

- 11.9.2 All pipes, fittings, flushing cisterns, valves, stop cocks, taps, tanks, surface boxes etc., to be of the best of their kinds and in addition to complying with previous clauses to be from approved manufacturers and all taps, cocks, valves etc., to be screwed down pipe. All tanks to be made fly-proof and to the complete satisfaction of the Engineer. All lavatory basins, sinks etc., must be fixed at least 12mm, the latter method of fixing is preferable. Rates should include for all cutting and waste, bends, taps junctures, cleaning eyes, tees.

11.10 Manholes and Manhole Covers and Frames

All manhole covers and frames shall be as per the relevant duty class (as per BS EN 124) as mentioned in the BOQs.

11.10.1 Concrete cover slabs or top rings of manholes shall provide a suitable seating for a rectangular cover and frame having a clear opening 0.61m x 0.457m or alternatively a circular or double triangular cover and frame having a clear opening of 550mm dia depending on the type of c.i manhole cover to be used, and the rate for manholes shall allow for such provision.

11.10.2 Where the supply of c.i manhole cover and frames is not payable separately the cost of setting, surrounding, painting and materials for same shall be allowed for in the rate for manholes.

11.10.3 Suitable lifting rings, hooks or brackets shall be provided in the precast manhole sections. Box holes shall be separately grouted with 1:2 cement mortar.

11.10.4 The Contractor shall supply two manhole keys for each pattern of cover without additional charge over the rate for covers (or manholes).

11.10.5 Heavy duty (grade a) cast iron manhole cover and frames shall be of the double triangular type to b.s and having a clear opening of 550mm dia.

11.10.6 Medium duty (grade b) cast iron manhole covers and frames shall be of the circular type having a clear opening of 550mm dia or the rectangular type having a clear opening of 0.457m x 0.61m and conform to bs. They shall be of the single seal type, the weight of cover frame being approximately 127.00 kgs.

11.10.7 Light duty (grade c) cast iron manhole cover and frames shall be of the double seal flat type having a clear opening of 0.457m x 0.61m conforming to BS. Weight of cover and frame approximately 50.75kgs.

11.10.8 All manhole covers and frames shall be supplied, coated with a black bituminous composition and be given two coats of bituminous paint after bedding.

11.10.9 No extra rate is payable for drop and/or junction manholes but piping in and surrounds of drop lines are payable at that relevant rates for sewer piping and manholes.

11.10.10 In drop manholes where the difference in level between the incoming drains and the sewer does not exceed 0.610m in 75mm and there is sufficient room in the manhole, the connecting pipe may be brought directly through the manhole wall, and the fall accommodated by constructing a ramp in the benching of the manhole. The ramp shall be of concrete and finished equal to that of the benches. No extra rate is payable.

11.10.11 All swg gravity sewer lines should be, connected through an intercepting

manhole before connecting to the main sewer line, and the dimensions of the manhole and trap to be in conformity with mwsc.

11.11 Fixtures and accessories

11.11.1 Maker, class and colour shall conform to the drawings and particular specifications or the instructions of the Engineer.

11.12 As-Built Drawings

11.12.1 The Plumbing Contractor, shall mark down with red pencil on two sets of plumbing plans all the revisions, omissions and/or additions to the various plumbing installation drawings as the construction progress. One set of the plans as marked shall be submitted to the Engineer after completion of the work.

11.12.2 Before the final payment is made to the Contractor, he shall submit to the Owner two sets of all As-Built Drawings incorporating the changes made and noted in the marked plans retained by him. The As-Built Drawing incorporating all the changes made and noted in the marked plans retained by him. The As-Built Drawings shall be prepared on reproducible form.

11.12.3 The Plumbing Contractor shall prepare and submit the As-Built Drawings without extra cost to the Owner.

11.13 Miscellaneous

11.13.1 Throughout the construction period, open ends of all installed pipelines shall be kept closed by temporary plugs. Drainage lines shall not be used to conduct dirty construction wash-washer, especially, those with cement, to avoid possible clogging.

11.13.2 A temporary fire protection system at each building shall be provided by the Contractor during the construction period. This shall be of sufficient capacity to put out any fire that may break out at any of the building floors due to construction period. This in addition to temporary fire extinguishers required.

11.13.3 A temporary potable water supply shall be available to construction workers at each building floor as construction work progresses.

11.13.4 A temporary human Excrete Disposal System shall be provided by the Contractor to serve the workers during the construction period.

12. MECHANICAL

12.1 General

12.1.1 Scope

- 12.1.1.1 The work covered by the part of this part of specifications consist in performing all operation in connections with the supply and installation of the air conditioning and ventilating system, complete in strict compliance with the specifications and applicable drawings and subject to terms and conditions of the contract.
- (a) Work include furnish and install VRV & single split Air Conditioning units and ventilation systems to general areas to include, lobbies, entrance ways, switchboard/electrical room, office spaces, facility providing premises to the cold room, vaccine packing area, conference room, auditorium area and lift machine room.
 - (b) Furnish and install ceiling Ventilating Fan to pump rooms, toilets and fresh air ventilating system in office areas as shown on drawings
 - (c) Furnish and install ventilating air duct system
 - (d) Furnish and install refrigerant piping system
 - (e) Furnish and install Electrical power and control system as shown in the plans.
 - (f) Testing, balancing and commissioning of the system.

12.1.2 General Conditions

- 12.1.2.1 The contract drawings indicate the extent and general arrangement of the air conditioning and ventilating systems. If departure from the drawings is deemed necessary by the Contractor, details of such departures and reason therefore shall be submitted to the Engineer for approval. No such departure shall be made without the prior approval of the Engineer or his representative.

12.1.3 Standard Products

- 12.1.3.1 The Contractor shall submit, as soon as practicable after award of contract, a complete schedule of equipment for installation shall be submitted to the Engineer or his representative for approval prior to purchase of these units. Equipment shall be a standard product of a reputable manufacturer. Air conditioning system shall be Daikin, Hitachi, Mitsubishi or similar.

12.1.4 Shop drawings

- 12.1.4.1 As practicable, after award of contract and prior to installation, a complete shop drawings, showing the sizes and type of equipment,

together with complete piping layout and electrical power requirement shall be submitted to the Engineer or his representative for approval. This holds true also for air duct system.

12.1.5 Government permit and Certificate of Inspection

- 12.1.5.1 Prior to start of installation, the Contractor shall secure a permit to install from the authorization agency having jurisdiction over the place of installation and before final acceptance by the Employer. Fees and other expenses incurred due on these permits shall be borne by the Contractor.

12.1.6 Local Laws and Ordinances

- 12.1.6.1 Aside from herein specified the equipment and installation materials, installation of the system shall confirm to local Laws, Codes and other ordinances that are in force in the country.

12.1.7 Description of System

- 12.1.7.1 The air conditioning system shall be VRV for the general office spaces and lobbies and the rest shall be single split type air conditioners.
- 12.1.7.2 Fan Coil units shall be of Ceiling Mounted type, horizontal throw and cabinet model as specified.
- 12.1.7.3 Air Handling Units shall be vertical discharge type and ceiling hanging type as shown in the drawings. Relevant HEPA purification and SS 304 ducts shall be used as shown in the drawing.
- 12.1.7.4 All condensing units shall be designed for outdoor installation with anti-corrosive treatment. All PC boards in VRV outdoor units shall be corrosive protected.
- 12.1.7.5 Electrical power supply shall be 230 volts, 1 phase, 60 hz. for the equipment and 400volts 3phase 50Hz respectively.

12.1.8 Description Of Equipment

- 12.1.8.1 VRV outdoor unit shall be treated with anti-corrosion paint, specifically for use in salty conditions. Especially the heat exchanger shall be treated with anti-corrosion treatment.
- 12.1.8.2 The unit shall be supplied with diverter hood on the air outlet side, if top of the outdoor unit is covered by top slab covering.

12.2 Materials and Installation Procedures

12.2.1 Piping System

12.2.1.1 Refrigerant and Condensate Piping

- 12.2.1.1.1 Refrigerant pipe shall be type L hard drawn seamless copper, suitable for a working pressure of 2413 kPa. Fittings shall be

wrought copper or brass designed for use of high temperature solder and suitable for working pressure of not less than 2413 kPa. Joints from soldered to threaded joints shall be made with a standard adapter fittings using high temperature solder. Pipes and fitting shall be cut accurately to measurement established at the building lines. All piping shall be laid straight and no piping or tubing shall be laid against other materials without insulation. After cutting, the tubing shall be reamed, all burred removed and internal surface internally cleaned. While soldering pipes and fitting together, a continuous flow of inert Nitrogen gas must be applied to sweep the internal surface of the tubing to avoid the formation of oxide inside.

12.2.1.1.2. Condensate drain piping shall be insulated PVC pipe. A P-Trap with a clean out plug shall be provided at the outlet of each pan.

12.2.1.1.3. Pipe support and hanger shall be provided and fabricated in a workmanship manner out of angle bar, rod, and flat bar. Metal to metal contact between pipes and hangers shall be avoided by providing 3mm thick rubber in-between. Supports on horizontal lines shall spaced at not more than one meter on center. All piping shall be anchored so that no stress is placed on the equipment connection by expansion.

12.2.1.1.4. Pipe sleeves shall be of standard steel pipe with sufficient diameter to provide minimum clearance of 6mm around the pipe and in the case of insulated pipes approximately 6mm around the insulation. Pipe sleeve shall be installed whenever pipe penetrates a masonry or concrete wall and floors. Pipes shall not be permitted to penetrate walls, beams, or column unless permitted by the structural Engineer.

12.2.1.2 Vibration Absorbing Foundation

12.2.1.2.1. All times for mechanical equipment such as Air cooled condensing unit shall be properly isolated from the building structure by means of Vibration absorbing foundation. Each foundation shall include an adequate number of standard isolation units or as specified by the equipment manufacturer.

12.2.1.3 Valves and Pipe accessories:

12.2.1.2.2. Refrigerant Valves

Valves shall be installed in the suction and discharge lines adjacent to the compressor or unless built-in valves are furnished on the liquid line of the discharge side of the condenser. Valves shall be wrought copper or brass for use with R-22 and suitable for a working pressure of 350 psi.

12.2.1.2.3. Thermostatic Expansion Valves

Expansion valve of proper capacity shall be installed in the refrigerant supply line to the evaporator. They shall be of the diaphragm type externally equalized and shall be such optimum size as to maintain a full active evaporator under all load condition and yet reduce the possibility of flooding the compressor with refrigerant during loads.

12.2.1.2.4. Solenoid Valves

Solenoid shall be installed as required and shall be designed for the operating pressure of the system. Valve capacities shall be based on the pressure drop across them but not to exceed 3 psi.

12.2.1.2.5. Dehydrators

Dehydrator in combination with strainer shall be installed in the refrigerant line to indicate whether or not the system are properly charged and to monitor the dryness of the system.

12.2.1.4 Air Duct System

12.2.1.4.1. Duct shown in the drawing, specified or required for ventilating system shall be constructed and erected in a first class workmanlike and air tight manner, all in accordance with the recommendation of CIBSE. Sheet metal thickness for different duct sizes shall be in accordance with the standard guides.

12.2.1.4.2. Unless otherwise directed by the Engineer, ducts shall conform accurately to the dimension and reasonably true to the locations indicated in the drawings. The duct shall be straight and smooth in the inside with joints neatly finished and air tight.

12.2.1.5 Hangers and supports

12.2.1.5.1. Ducts shall be braced and reinforced with angles, supported and securely anchored to the building in an approved manner so as to be quite and completely vibration free.

12.2.1.5.2. Curved elbows shall have a centreline radius of not less than 1-1/2 times the width of the duct. Splitter damper and turning vanes shall be constructed one gauge heavier and of the same material as to the duct in which they are installed. Turning shall be double thickness type. Splitter dampers shall be provided with lubricated bearing in both ends of the shaft and externally adjusted with locking devices.

12.2.1.5.3. Horizontal ducts shall be supported by 25mm x 25mm x 3mm flat mild steel bar if under 760mm wide and 25mm x 25mm x 3mm angle mild steel if under but not to exceed 2430mm. The bracing shall be use by extending the vertical portion. Vertical ducts shall be supported on the floor slab or structural steel member.

12.2.1.6 Fire Dampers

12.2.1.6.1. Fire dampers shall be provided in every duct that passes through firewalls or where indicated in the plans. Fire dampers shall be fabricated from heavy gauge black iron sheets as shown in the drawings and equipped with fusible ink set to melt at 73.88 C. the details of the construction is shown in the drawing. Access door at fire dampers shall be large enough and so located that damper blades may be repositioned and fusible link replaced.

12.2.1.7 Flexible Connectors

12.2.1.7.1. Flexible connectors shall be provided between ductwork and equipment to which they are connected to prevent the transmission of vibration. Materials shall be heavy canvass cloth closed weaved so as to rendered practically airtight. The necessary angles, bolts, clips and other fastening for securing the flexible materials to the equipment and air duct shall be provided.

12.2.1.8 Diffuses and Grilles

12.2.1.8.1. Supply and exhaust grilles shall be double deflection horizontal and vertical face bars. They shall be fabricated from gauge 20 B.I. sheets, bonderized after fabrication and finished with baked on enamel paint. Exhaust and fresh air louver shall be fabricated of the same materials as the grilles and shall have curved and hammed edges to give attractive appearance as well as rigidity and strength. The curved blades shall be stationary or fixed type.

12.2.1.8.2. Supply air diffusers for the kitchen for the kitchen working area shall be ceiling perforated model fabricated and install as on the mechanical plans.

12.2.1.9 Flexible Air Ducts

12.2.1.9.1. Flexible round duct shall be annealed Aluminium formed into multiple corrugation and encased with 25mm fibreglass insulation with aluminium reinforced foil. Ducts shall be suitable for negative or positive operating pressure of 500 Pa water gage.

12.2.1.10 Duct Insulation

12.2.1.10.1. All air handling, ducts shall be insulated with 60mm Fibreglass insulation, 48 kg/cm with factory applied reinforced Aluminium foil. Refer to mechanical plans for installation details. All air conditioning ducts shall be insulated with flexible elastomeric nitrile rubber insulations.

12.2.1.11 Finishing Works

12.2.1.11.1. Pipe hangers, un-insulated piping and other ferrous materials that has not received factory painting shall thoroughly be cleaned and given two coats of rust preventive paint.

12.3 Test and Adjustment Works

- 12.3.1 Upon completion of installation and when the system is ready for operation, capacity and general operating test shall be conducted by a competent and experienced Engineer to be furnished by the Mechanical Contractor. These test shall demonstrate the specified capacities if the equipment.
- 12.3.2 A direct reading velocity instrument, that has recently calibrated, shall be used to show the air flow in the areas that has been regulated as to deliver the required air quantities at their respective supply and exhaust outlet. Supply air temperature, motor load and speed shall be taken and to relate to the specified equipment. The Contractor shall furnish all necessary instrument such as ammeter, voltmeter, pressure gauges, tachometer and other instrument to enable him to carry out the comprehensive test of the equipment and the system.

12.4 Guarantee

- 12.4.1 The air conditioning and ventilating system and equipment furnished and installed under this part of specifications shall be guaranteed for period of one (1) year from the date of acceptance thereof. Materials furnish and workmanship shall be free from defects and same shall guaranteed for one year from the date of acceptance. At any time within one year after acceptance and upon proper notice, the Contractor shall rectify any and all deficiencies including replacement of parts or the entire unit without additional cost to the Employer, if such deficiencies have been caused directly or indirectly by inferior materials, faulty workmanship and or defective design of parts. During the guarantee period the Contractor shall perform free monthly inspection and make necessary adjustment if necessary for efficient operation of the system. Expendable materials such as refrigerant, oil, belt and air filters are included in this one (1) year guarantee.

13. LIFT

Please refer Vertical Transportation under MEP Special Specifications

14. ELECTRICAL INSTALLATIONS

14.1 General

- 14.1.1 The work shall be carried out strictly in accordance with the standard specifications and shall also conform to the requirements of electricity rules in force in Male', republic of Maldives.
- 14.1.2 All materials to be used in the works shall be of standard make and shall bear the certification marks of their respective testing or regulatory authority. All materials shall be approved by the Engineer before use in the works.
- 14.1.3 Earthing shall invariably be done in the presence of the Engineer or his representative. Earth impedance to be maintained as per standards.
- 14.1.4 All the conduits shall be continuously earthed. Check nuts shall be provided at the point where the conduct enter the I.C. box and junction box.
- 14.1.5 The Contractor shall arrange for the inspection of all medium pressure installation by the Electrical Inspector of the local electric supply authority from where the electricity connections has to be obtained, and see that they are passed by him. All the expenses for this testing shall be borne by the Contractor
- 14.1.6 The Contractor shall be responsible for all necessary permits, approvals, fees, deposits etc., Required to complete the electrical works in accordance with the contract.

14.2 Scope Of Work

- 14.2.1 The work consist of furnishing all tools, plants, labour, materials and equipment and performing the internal electrical Works comprising of:
 - (a) Light and power wiring
 - (b) Fans and fixtures
 - (c) Wires and Cables
 - (d) Fire Alarm System
 - (e) Telephone System
 - (f) Sub- Station Equipment:
 - (g) Distribution Fuse gear
 - (h) Earthing System
 - (i) Lightening Protection System
 - (j) Air Conditioning System
 - (k) Computer cabling system
 - (l) Emergency generator

14.3 Prequalification

14.3.1 The Electrification Work shall be carried out only by a licensed Contractor authorized to undertake such work under the Maldives Electricity Bureau.

14.3.2 A licensed Electrical Contractors shall have the following qualifications:

- (a) Must have in his employment a competent Electrical Engineer registered with Maldives Electricity Bureau.
- (b) Must have in its employment an Electrical Engineer having certificate of competency who will exclusively supervise this work.
- (c) Must have necessary tools, plant and instruments.
- (d) Must have adequate experience of similar works.
- (e) If a Contractor does not possess the above qualifications he shall be allowed to sublet the Work to a competent Sub-Contractor provided an application for his pre-qualification is made to the Engineer for his approval. Decision of the Engineer in this case shall be binding on the Contractor.

14.4 Rules and Regulations

14.4.1 The installation in general shall be carried out in conformity with the Electricity Rules, 1937 (UK), and the latest edition of the Regulations for the Electrical Equipment of Buildings issued by the Institution of Electrical Engineers, London (I.E.). However, in case of conflict between these Specifications and the I.E. Regulations, these Specifications shall be followed.

14.5 Standards

14.5.1 The latest relevant British Specifications, and I.E. recommendations shall be applicable and be followed for the equipment specified herein.

14.6 Climatic Conditions

14.6.1 All equipment supplied shall withstand, without developing any defect, the following climatic conditions:-

Maximum Ambient Temperature	=	113° F or 45° C
Minimum Ambient Temperature	=	28° F or - 2.2° C
Maximum Humidity	=	98%

14.7 Specifications

14.7.1 The Contractor shall furnish all material and equipment at site, confirming fully to the specifications given herein and to the accepted standards, the Institution of Electrical Engineers, London, and the Maldives Electricity Bureau. It is not the intent of these Specifications to include all details of design and construction of various material and equipment to be supplied under this contract. The Contractor shall supply and install all material and equipment specified herein and also all installation and small material such as nuts, bolts, washers, shims angles, levelling material, insulation, tape, solder, etc. and all such required for complete installation as intended by the Specifications.

14.7.2 The Contractor shall provide for all the required technical and non - technical personnel, skilled and non - skilled labour, construction equipment, transportation etc., as required for the completion of Work in strict accordance the Technical Specifications laid hereinafter. All material and equipment supplied by the Contractor shall be new and in all respects conforming to the high standard of Engineering design and workmanship. All material and equipment which have to be supplied and installed by the Contractor shall be passed/approved by the Engineer; even if the same is exactly in accordance with the Bill of Quantities and Drawings.

14.8 Submittal

14.8.1 The Contractor, after the award of work, shall submit for approval of the Engineer all drawings and cuts of equipment, appliances, fixtures and accessories. Cuts, catalogues and drawings shall be clearly marked to indicate, the items furnished.

14.9 Drawings and Data

14.9.1 Approval of Drawings and Data

14.9.1.1 The Contractor shall provide detailed electrical drawings, wiring diagrams, etc. for all electrical switchgear, fuse gear and all other systems etc. for the Engineer to review and approval. Three sets of equipment drawings shall be provided for obtaining approval. These drawings shall be signed by a Licensed Electrical Engineer.

14.9.2 Drawings and Data

14.9.2.1 Three sets of drawings and data for each equipment shall be furnished by the Contractor for the Engineer approval before commencement of work. The drawings to be supplied by the Contractor shall be as follows:-

14.9.2.2 Electrical Drawings showing:-
(a) Single-line diagram of all switchboards & distribution boards
(b) Detailed wiring diagram
(c) All interconnections
(d) Relays, their locations, and internal wiring diagrams
(e) Other electrical devices including meters instruments and their wiring diagram

14.10 Shop Drawings

14.10.1 The design drawings do not show conduit routes and depict only the position of various fixtures and outlets. All the planning for the conduit routes shall be carried out, well in advance of the actual execution of work, by the Contractor to the satisfaction of the Engineer. For this purpose the Contractor shall prepare shop drawings and obtain prior approval of the Engineer. Three prints of each shop drawings shall be submitted for obtaining approval before commencement of work.

14.10.2 No piece of work shall be allowed to be executed at site without the availability of these approved shops drawings. These shop drawings shall clearly depict the load balancing chart of each Distribution Board. Time required for the preparation and approval of shop drawings shall be considered to have been included in the total time allowed for the completion of the work.

14.11 Spare Parts List

14.11.1 A list of spare parts required for the one year's operation of each equipment where deemed necessary together with unit price of each part, shall be supplied by the Contractor.

14.12 Guarantee

14.12.1 The Contractor shall furnish written guarantee in triplicate of the manufacturer for successful performance of each equipment. Such guarantee shall be for replacement, which may be found defective in material or workmanship. The guarantee shall cover a minimum period of 12 months effective from the date of completion certificate.

14.13 As-Built Drawings

14.13.1 The Contractor shall, during the progress of work keep a careful record of all changes and where the actual installation differs from that shown on shop drawings. These changes and revisions where the actual installation differs from that shown on shop drawings. These changes and revisions shall be accurately carried out on the shop drawings and submitted to the Engineer for approval. After approval these drawings shall become the property of the Owner. These updated and approved shop drawings depicting clearly all changes and revisions made on site shall be called As-Built Drawings. Reproducible tracings of all these As-Built Drawings shall be handed over to the Engineer in the form of a bound document. Final payment will be withheld until the receipt of the approved As-Built Drawings.

14.14 Test Reports

14.14.1 The Contractor shall be responsible for the submitting the test reports/certificates and get the installation inspected passed by STELCO

14.15 Conduits and Accessories

14.15.1 Conduit Pipe

14.15.1.1 The conduit for the wiring of lights, socket outlets and other systems shall be made of PVC conforming to BSS 3505/1968 Class-D.

14.15.1.2 The conduit shall have following wall thickness and standard weights:

Pipe Size	Wt/100Rft.	Wall thickness
20mm dia	3.4 Kg	0.04 to 0.05
25mm dia	4.5 Kg	0.045 to 0.055

14.15.1.3 Steel conduit shall conform to BSS 31/latest. The conduit shall be enamelled with good quality non- cracking and non-flaking black paint.

14.15.2 Conduit Accessories

14.15.2.1 The use of factory made round PVC junction boxes shall be used and should have nipples to receive PVC pipe with force fit, shall be used for ceiling outlets. The wall type junction box shall also be PVC. Each junction box shall be provided with one piece cover which shall be fitted on the box with screws.

14.15.2.2 Conduit accessories such as switch boxes, socket outlet boxes, pull boxes and inspection boxes shall be made of PVC having dust tight covers. All boxes shall have required number of conduit entry holes. All the rectangular or square shaped boxes shall have nipples to receive PVC conduit force fit.

14.15.2.3 Manufactured smooth bends shall be used where conduit changes direction. Bending of Conduit by heating or otherwise shall be allowed only at special situations with the permission of the Engineer. Use of sharp 90 degree bends and tees is prohibited. Bends shall have enlarged ends to receive the conduit without any reduction in the internal diameter of the PVC pipe.

14.15.2.4 All accessories e.g. boxes, coupling, bends, solid plugs, bushes, reducers, checknuts etc. shall be equal in quality to the specified conduit.

14.15.2.5 The drawings do not show conduit routes and all the planning for arranging conduit routes shall be carried out by the Contractor to the satisfaction of the Engineer.

14.15.2.6 The entire conduit system shall be essentially completed before the wiring pulling is taken in hand. Each conduit run shall be tested for continuity and obstructions. All obstructions shall be cleared in an approved manner. Water and moisture that has entered any section of the conduit installation must be dried with suitable swabs to the satisfaction of the Engineer.

14.15.2.7 Adequate expansion joints shall be provided in all conduit runs passing across the expansion joints in the concrete slab of the buildings.

14.15.2.8 All the free ends of conduit shall be solidly plugged till such time as final and proper terminations are made.

14.16 Wires, Cables and Codes

14.16.1 Wires & Cords

14.16.1.1 The wires & cords for the conduit wiring shall be single core, made of stranded copper conductors, PVC insulated, tested to B.S. 6004, 1975. The voltage grade shall be 300/500 volts or 450/750 V unless otherwise specified on Drawings and Bills of Quantities.

(a) For light or fan point wiring with 1.5 mm square or as specified in the BOQ.

(b) For power plug 15A wiring with 4mm square or as specified in the BOQ.

14.16.2 Installation Instructions

14.16.2.1 All wiring shall be continuous between terminations and use of connectors or joints shall not be used. Spur and tee connections are strictly prohibited.

14.16.2.2 Manufacturers recommended lubricant might be allowed to facilitate pulling of wires. Use of any kind of oil and soap is prohibited.

14.17 Wiring Accessories

14.17.1 Switches

14.17.1.1 Indoor switches controlling lights and fans shall be single pole, 5A, one or two way, suitable for 250V, 50 Hz. The body of the switches shall be made of moulded plastic, one, two, three or four gang with integral built in moulded plastic face plate.

14.17.1.2 Weatherproof switches shall conform to B.S. standard.

14.17.2 Switch Socket Outlet Units

14.17.2.1 Switch & socket units shall be single, pole, 3 pin rated 5A, 15A or 20A, 250V, 50 Hz. These shall be moulded plastic type with white integral built-in faceplate. Each socket shall have its control switch by the side of it on a common faceplate. Thus the complete unit specified in BOQ shall be as switch and a socket outlet unit.

14.17.3 Dimmer

- 14.17.3.1 The dimmer shall be recessed type as required and shall be approved by the Engineer.

14.18 Light Fixtures

14.18.1 General

- 14.18.1.1 The description of light fixtures is given in the Bills of Quantities, and stated on the Drawings, and all relevant material are described in this Section. The determination of quality is based on certified photometric data covering the coefficient of utilization, light distribution curves, construction material, shape, finish, operation, etc.
- 14.18.1.2 The Contractor shall submit samples and technical specifications of each and every lighting fixture specified for approval of the Engineer.
- 14.18.1.3 The type of fixtures with manufacturer catalogue reference are given in Bill of Quantities. The lighting fixtures shall be manufactured by M/s. Philips, M/s.RZB Lighting Thorne Lighting (Thorn: http://www.thorn.com.hk/thorn_ww/index.html) or equivalent and as approved by Engineer.

14.18.2 Incandescent Light Fixture

- 14.18.2.1 The glass globes/ shades/ diffusers of the incandescent light fixtures shall be first class quality glass free from any air bubbles or voids. The glass shall generally be of opal white colour unless otherwise specified. The shape of the glass may be spherical, hemispherical, flattened bottom or tablet shaped as required.
- 14.18.2.2 Surface mounted fixture shall have stove enamelled sheet steel body. It may also be satin brass or aluminium anodised finish as required. The fixing holes shall match the outlet box. Wall bracket light fixtures shall have back plates with matching holes of the outlet box and decorative finish as required.
- 14.18.2.3 All the lighting fixtures shall be suitable for local climatic conditions.

14.18.3 Fluorescent Light Fixture

- 14.18.3.1 All the light fixtures shall have lamps and electronic ballasts of the wattage specified. The fluorescent lamp shall be either 2 ft - 18 watts or 4 - 35 watts and the colour shall generally be day light, cool day light in the order of preference or as mentioned specifically. The fluorescent lamps shall be Philips to BSS 1853 but having a minimum useful life of 5000 hours. The new generation of 26mm dia 18 watts and 36 watts energy efficient lamps shall be preferred.

- 14.18.3.2 The ballast shall be totally enclosed electronic type suitable for operation on 220 V, 50 Hz, single phase supply, a wiring diagram, wattage, voltage and current ratings shall be printed on the body of the ballasts. The power loss shall not be more than 10 watts for 36 watts ballast. The ballast shall be noiseless in operation without any whistling sound. The manufacture shall be called upon to guarantee a trouble free life of 3 years, effective from the date of completion certificate.
- 14.18.3.3 The starters shall have radio-interference suppressers.
- 14.18.3.4 The internal wiring of the light fixtures shall be carried out at manufacturers factory with heat resistance wires of size not less than 1.5 mm square.
- 14.18.3.5 The louvers of light fixtures shall be made of anodized aluminium and/or moulded plastic. The diffusers shall be made of acrylic perspex.
- 14.18.3.6 All the lighting fixtures shall be suitable for local climatic conditions.

14.18.4 Installation Instructions

- 14.18.4.1 The light fitting shall be installed according to manufacturers recommendations or as approved by the Engineer.
- 14.18.4.2 Flexible connecting wires from outlet box to the fixture shall be provided by the Contractor; connector made of porcelain or thermoplastic material shall be provided and installed in the outlet boxes for connecting flexible wires to the point wires.
- 14.18.4.3 Outlet boxes or any openings in the ceilings and walls shall be covered with appropriately fabricated accessories to provide an Architectural entity to conceal them.

14.19 Main L.T Switchboard

14.19.1 Type of Main L.T Switchboard

- 14.19.1.1 The L.T. switchboard (panel board) shall be indoor type, free standing, free supporting, floor mounted, totally enclosed, sheet clad, dust and suitable for operation on 3 phase 4 wire system, 415 v , 50 Hz, AC supply . The boards shall be suitable for installation back to the wall and capable of front attendance. The switchboards shall be designed to suit service conditions and ensure security and safety during operation, inspection operation, cleaning and maintenance. The switchboards shall be designed and tested to IEC recommendations. Each panel shall withstand strain of 2000 volts insulation level for one-minute power frequency test.
- 14.19.1.2 The L.T. switchboard shall consist of the following:

(a) State Electric Company incoming panel.

14.19.2 Distribution Feeder Panel

14.19.2.1 Single line diagram of the L.T. switchboard shall be approved by the Engineer before placing order for the switch board.

14.19.3 Earthing

14.19.3.1 The switchboard shall be effectively earth by means of a copper strip of 25mm x 3mm (1" x 1/8") cross -section bolted to connections near the bottom of the switchboard.

14.19.4 Accessories

14.19.4.1 Designations labels, lifting lugs, foundation bolts, interconnecting nuts bolts, and washers, thimbles, lugs, levelling shims cable glands and/or cable end box for all the sizes of incoming and outgoing cable shall be supplied with the switchboard.

14.20 Switchboard Testing

14.20.1 The following tests shall be conducted on each completed switchboard

14.20.1.1 Type Tests

- (a) Temperature rise test
- (b) Mechanical endurance test
- (c) Making/Breaking Capacity test

14.20.1.2 Routing Test

- (a) High Voltage test

14.20.2 The Switchboard shall be tested to British/Electricity Council Standard 41-5. Preference shall however, be given to Switchboards fabricated from all components manufactured by only one manufacturer.

14.20.3 Installation Instruction

14.20.3.1 All labour, equipments, tools and plants required to complete the installation shall be provided by the Contractor. The Switchboard shall be fixed firmly on the floor in perfect line, plumb and level position. All incoming and outgoing cable connections shall be made from the bottom including Earth connections.

14.21 Distribution Board

14.21.1 The distribution boards / consumer units shall be either free standing, cubical type or wall mounting type suitable for recessed mounting. Each distribution board / consumer unit (d.b.) Shall be tropical in design, fully dust and vermin proof and liquid repellent.

14.22 Power Supply

14.22.1 Package substation as specified in drawings

14.23 Fire Alarm System

14.23.1 General

14.23.1.1 The Contractor shall be under obligation to plan, supply, install, test, commission and maintain for the period specified elsewhere, a fire alarm system for this building. The proposed system shall consist manual call points & alarm bells on every floor. Ionisation/optical smoke detectors at Electric room office area and lobby. Maintenance room & pump room. Plus Fire alarm control panel at ground floor guards room.

14.23.2 Specifications

14.23.2.1 The system shall facilitate the detection of fires occurring in any part of the building by subsequent audible and visual indications. The system shall generally comprise of the following :-

14.23.3 Main Control Panel

14.23.3.1 The control panel will be perspex fronted panel and will display all screened labelling and indications by block LEDs mounted behind the front hinged cover. The control panel shall be mounted in pressed steel housing and provide the following functions and indications.

14.23.3.2 Fully monitored two wire circuit for each sensor zone (24V D.C.) as required.

14.23.3.3 Fully monitored two wire sounded circuit (24V D.C.) as required.

14.23.3.4 Change over relay contacts each rated 5 amps 240V A.C. (Resistive load).

14.23.3.5 Full test and isolate functions via a key-board located on the fascia of the main termination housing to provide the following:-

14.23.3.6 Ability to isolate sensor zones.

14.23.3.7 Ability to isolate sounder zones.

14.23.3.8 Ability to test automatically zones with an auto reset facility to enable a single person to carry out testing.

14.23.3.9 Full LED display of all functions comprising of:-

System on, system fault, processor fault, alarm, zone supply fault, system supply fault, battery fault, charger/mains fault, sounder fault and sensor fault together with a test mode display which provides zone clears, zone

open circuit and zone short circuit indication for individual sensor and sounder (bells) lines.

- 14.23.3.10 Sequence of sounder operation- All sounder (bells) and relay out-put sequences shall be completely programmable to enable future changes to be carried out with only soft ware changes.
- 14.23.3.11 The control panel shall provide the following functions and indications:-
- a) Twin LED display for system on, system fault, sounder fault, alarm, mains/ charger fault, main processor fault, sensor fault, alarm silenced, battery fault, supply fault and earth fault.
 - b) Also five dedicated control functions on illuminated push buttons, which are key - isolated. These shall provide Evacuate, Buzzer Mute, Alarm silence, Lamp test and Reset controls.
- 14.23.3.12 Battery charger - the battery charger shall be an integral part of the main fire alarm control panel cabinet and shall be capable of fully recharging the stand - by batteries after a main's failure within 12 hours. The capacity of the batteries shall be sufficient to supply the standing load for the least 24 hours and the maximum alarm load for one hour. The system shall be suitable for operation on 220v single phase or 415v , 3- phase 50 hz supply.

14.23.4 Sensors and Sounders

- 14.23.4.1 The main control panel as described in the foregoing shall be capable of working with the following devices having common specification as under :-
- | | |
|-------------------------|--|
| (a) Operating voltage | 10-30 volts d.c (two wire system) |
| (b) Ambient temperature | 10 C to +80 C. |
| (c) Humidity range | 20 to 90 RH |
| (d) Altitude range | Sea level to 6000 meters |
| (e) Alarm mode | Self latching producing a resistance of 680 ohms across the supply line. |
- 14.23.4.2 Photocell (optical) smoke detectors- the units shall operate on light scattering principle. An internal infra-red light source shall be pulsed, with the light beam ranged so as to by-pass a receiving unit. The presence of smoke shall scatter the light beam, causing it to be reflected on to the receiving photocell. An evaluation circuit shall measure the amount of light and shall compare it to a reference. The detector shall trigger in to an alarm state when the amount of smoke exceeds a pre-set level. To ensure against false alarms several pulse readings shall be taken and compared before the detector shall be triggered into alarm. The detectors shall conform to b.s.s. 5446 part -1 and shall have the following specifications:-

(a) Quiescent Current	Less than 100 microamps at 20 volts.
(b) Alarm Current	Maximum 60 mA
(c) Maximum Coverage	300 cubic meters
(d) Weight	250 grams approx.
(e) Diameter x Height	92 mm x 80 mm

14.23.4.3 Manual stations - this unit also named call point shall be break glass type that do not require a hammer. The frangible glass is pressed hand to break the glass, which shall activate the alarm. The call point shall conform to b.s. 5839 part-2

14.23.4.4 Alarm bells - the alarm bells shall be centrifugal type and the gong shall be 100 mm diameter or as specified. The unit shall be suitable for an input of 24 v d.c. And shall provide a normal output of 94 db at 1 meter.

14.23.4.5 Electronic sounders - the unit shall be primarily designed to operated on 24v.d.c. And arranged easily to generate a variety of sound signals: intermittent, continuos or warble tones.

14.23.5 Wiring

14.23.5.1 The wiring for the fire alarm system shall be carried out in PVC conduit in accordance with instructions contained herein relevant section. 2x2.5 mm square or 4x2.5 mm square PVC heat resistance insulated single core cable 300/500 volts grade shall be pulled in 1” dia PVC conduit laid for the purpose. Any spurs and tee joints in the wiring are strictly prohibited. Instructions contained in section -E.2.2 and 2.3 shall be followed.

14.23.6 Installation

14.23.6.1 The installation as a whole shall be tested and commissioned, in accordance with manufacturers instructions, to the entire satisfaction of the Engineer.

14.23.7 Shop Drawings

14.23.7.1 Shop drawing of the fire alarm system layout shall be submitted to the Engineer for approval.

14.23.8 Cable Ladder / cable tray System

14.23.8.1 General

13.23.8.1.1. The cable ladder system shall generally be installed in vertical riser ducts provided for the purpose for parallel runs of cables of various services. The cable tray shall be used on ground floor to run the cables to the respective riser ducts from electrical main panel.

13.23.8.1.2. The Contractor shall be under obligation to supply all labour, material and accessories for the completion of cable ladder installation strictly in accordance with the specification laid as under and as illustrated on drawing to the entire satisfaction of the Engineer.

14.23.8.2 Design

13.23.8.2.1. The cable ladder system shall be fabricated from 16SWG (2.5 mm) thick sheet steel strip and then hot dip galvanized. All fixing accessories e.g. rawl bolts, cable clamps, nuts and bolts used for the cable ladder system shall be hot dip galvanised. All cable ladder shall have standard length of 4000 mm and a width of 500 mm. The ladder and accessories shall be subject to the prior approval of the Project Manager before mass production is taken in hand.

14.23.8.3 Installation

13.23.8.3.1. The cable ladders shall be installed in perfect line and plumb on the surface of walls in riser ducts by means of galvanized rawl bolts 1/2" dia x 3" long. Alternate ladder step in each length of ladder shall be clamped to the ladder in a neat and orderly manner by means of cable clamps. Depending upon the number of multiple cable runs two or three parallel ladders may be installed, side by side, in the same riser ducts in case one ladder is unable to accommodate all the cable runs. Each cable ladder (or an assembly of two or three parallel cable ladders laid side by side) shall be solidly earthed with 1" x 1/8" copper tapes on both sides.

14.24 Lightning Protection System

14.24.1 General

14.24.1.1 The Contractor shall be under obligation to supply all labour material, services and skilled supervision necessary. Shop drawing for the lighting system shall be submitted to the Engineer at least 4 weeks before commencing the work.

14.24.1.2 The contractor shall furnish and install as shown in the plans a conduit system with conductors as shown in the drawings.

14.24.1.3 Both ends of each set of conductors shall be properly identified with durable tags with the same identifications of both ends, at the outlet and the telephone terminal cabinets to facilitate the installations of the telephone instrument in the future and for trouble shooting purposes. Cable used shall be twisted and shielded 3 cables in the office area and the rest as shown in the drawing.

14.24.2 Workmanship

14.24.2.1 The installation shall be carried out by skilled and competent workmen so as to achieve top class workmanship.

15. INFORMATION TECHNOLOGY NETWORK CABLING

Refer Extra Low Voltage system under MEP Special Specifications

SPECIAL SPECIFICATIONS

ARCHITECTURAL SPECIAL SPECIFICATIONS

1. Fire Doors
2. Tempered Glass
3. Glass For External Openings
4. Specification For Aluminium Works Doors & Windows
5. Specifications For Door Handles For Aluminium Framed & Tempered Glass Doors
6. Specifications For Sealant
7. Floor & Wall Tiles
8. Power Trowel Finished Floor
9. Machine Cut Concrete Floors
10. Stamped Concrete Floors
11. Epoxy Coating For The Floor
12. Granite Flooring & Vanity Counters
13. Painting
14. Aluminium Composite Cladding Panel Façade
15. Powder Coated Aluminium Decorative Mesh Façade
16. Roof Sheeting
17. Insulation For Roof Sheeting
18. Toilet System Partitions
19. Perforated Metal Sheet Ceiling
20. Mineral Fibre Ceiling
21. Metal Strip Ceiling
22. Plaster Board Ceiling
23. Specifications For Paving
24. Tilttable Roof
25. Glass & Stainless Steel Handrails
26. Stainless Steel & Aluminium Louvered Canopy
27. Fluted Metal Wall Panel For Lift Lobby Wall Façade
28. Building Maintenance System – Davit System

1. FIRE DOORS

All fire doors should be opened to the direction of the flow of people while on emergency. These doors should be installed with self-closing device including the Panic Latch. These Panic Latch devices should conform to BS 5725 Pt 1 or any other equable International Standard.

Fire doors conforming to the method of construction as stipulated below shall be deemed to meet the requirement of the fire-resisting period.

Doors and frames constructed in accordance with one of the following specification shall be deemed to satisfy the requirements for doors having fire resisting period of half-hour (30min.).

1. A single door 900 millimeters wide x 2100 millimeters high maximum or double doors 1800 millimeters high maximum constructed of solid hardwood core of not less than 37 millimeters laminated with adhesives conforming to either BS 745 “Animal Glues”, or BS 1204, “Synthetic resin adhesives (phenolic and amino plastic) for wood” Part 1, “Gap-filling adhesives”, or BS 1444 “Cold – setting casein glue for wood”, or any other equable International Standard, faced both sides with plywood to a total thickness of not less than 43mm with all edges finished with a solid edge strip full width of the door. The meeting stiles of double doors shall be rabbeted 12mm deep or maybe butted provided the clearance is kept to a minimum;
2. Doors may be double swing provided they are mounted on hydraulic floor springs and clearances at floor not exceeding 4.77mm and frame and meeting stiles not exceeding 3mm;
3. A vision panel should be incorporated provide it does not exceed 0.065 square meter per leaf with no dimension more than 1370mm and should be glazed with 6 mm Georgian wired glass in hard wood stops;
4. Doors constructed in accordance with BS459 part 3 : 1951 or any other equable International Standard, fire check flush doors and wood and metal frames (half hour type);
5. Timber frames for single swing half hour fire doors of overall width of 60 mm including 25 mm rabbet and Depth to suit door thickness plus 34 mm stop;
6. Metal frames for half hour fire doors shall be of sheet steel not lighter than 18 gauge of overall width 50 mm including 18 mm rabbet and depth to suit the door thickness plus 53 mm stop;
7. Timber or metal frames for double swing doors should be as specified above with minimum clearances between frame and door;
8. Double doors with rabbeted meeting stiles should be provided with coordinating device to ensure that leafs close in the proper sequence;

9. Fire doors may held open provided the hold open device incorporates a heat activated device to release the door. Heat activated devices shall not be permitted on fire doors protecting openings to protected corridors or protected staircase.

The Fire doors and its related devices should be approved by the MNDF fire and Rescue Service before Installation. Special permission should be taken if it is different from above.

2. TEMPERED GLASS

Tempered glass, also known as “fully tempered” or “thermally toughened” glass, is produced in the same way as heat strengthened glass, except that it is quenched more rapidly. This heat treatment results in a larger variation between the compressive stress at the surface and tensile stresses at the interior. After the heat treatment process, the surface compression stress should not be less than 69 MPa. When tempered glass breaks, it will fracture into small, roughly cubic fragments.

The surface compressive stress of tempered glass could be measured by the GASP. Tempered glass exhibits high values of bending strength because of the locked-in compressive surface stresses. In some cases, the design is controlled by deflections and the strength of tempered glass may not be fully exploited. Bolt holes do not cause large changes in surface stress, as long as their diameter is at least equal to the thickness of the glass. This enables cooling air to pass readily through the holes so that glass edges along the bolt holes cool at a similar rate as the parent glass pane. All cutting and drilling and grinding of glass must be carried out before the glass is toughened, in order to avoid glass shattering. Tempered glass has a better resistance against stress concentration at openings. Tempered glass is susceptible to “spontaneous breakage” due to Nickel Sulphide (NiS) inclusions inside the high tensile zone at the interior. The process causing breakage occurs when α -NiS particles are trapped in the tensile zone of the glass during production and transformed to the larger volume β -NiS phase. As the transformation continues the volume eventually increases and induces stresses in the glass pane causing spontaneous breakage. To avoid spontaneous breakage, tempered glass should go through heat soak process during its production as tempered glass containing NiS inclusions will break during the process and would not be put in use.

Safety requirement against glass breakage

1. Tempered glass or laminated glass should be used in the parts of building exterior façade also serving as protective barrier.
2. Where tempered glass is used in building exterior façade, the glass should be in the form of laminated glass if it meets the following conditions: (i) The size of glass pane exceeds 2.5 m² ; and (ii) Any point of the glass pane installed is at a height 5m or more above the finished floor level of the accessible area on either side of the pane.

SEALANT

Refer Item number 5 in the Architectural Special specifications

GLASS CONNECTION

Contact between glass and any other hard substance with hardness greater than the hardness of glass should be avoided. Gaskets or other glazing materials should be used with frame systems. Where bolted connections are used, it is essential to ensure that the glass does not come into direct contact with the bolt or the clamping plates. Proper bushing material shall be used in which its hardness shall be less than the glass material.

Framed infill glass pane

For fully framed or two-edged framed infill glass pane, the framed section should give a minimum of 10 mm edge cover, minimum 6 mm edge clearance and minimum 5 mm front and back clearances to the glass pane. The edge cover is recommended not less than the thickness of glass pane in contact. Reference can be made to BS 6262 or relevant design guidelines. The framed section and its connections to the main frame should be capable of withstanding the design load transferred through the glass panes.

Adhesive based connection

One of the most common forms of adhesive connection is the use of silicone to form glass-to-glass right angle butt joints. Such fixings allow the glass to rotate within the frame and are thus deemed to be simply supported for such a design of glass connections.

Point bolted supports

Tempered glass should be used and the position of the connectors should not allow the glass panes to undergo reverse curvatures, as these could lead to very high stress concentration at bolted connections. There should be clamping plates and gaskets on both sides of the glass panes that provide a minimum of 50 mm diameter cover to the glass panes. Where the length of a glass pane is greater than the span between the bolted connectors, giving rise to a cantilevered portion of the glass pane, the length of the cantilevered portion should be less than one-quarter of the span between the bolted connectors. The fixing of the bolted connectors to the main frame should be capable of withstanding the design loads transferred through the glass panes.

Placement of holes

1. The minimum distance from any edge of a glass pane to the nearest point on the rim of a hole must be 6 mm or 2 times the thickness of the glass, whichever is greater.
2. The minimum distance between the rims of adjoining holes must be at least 10 mm or 2 times the thickness of glass, whichever is greater.
3. Holes near corners must be located so that the nearest edge of the hole is at least 6.5 times the thickness of a glass pane from the tip of the corner when the corner is 90° or more.
4. Minimum dimension of holes – Circular holes must have a minimum diameter of 6.4 mm or the thickness of a glass pane, whichever is greater. In other than circular Holes, any corners must have fillets, the radius of which must be equal to or greater than the thickness of the glass pane.

GLAZING ACCESSORIES

Gasket

Gasket shall be compatible with other contact materials. Durability, compatibility, strength and ductility are required to be considered. Typical gasket types are given in Figure 7.9. Weather strips, glazing gaskets and glazing blocks shall be manufactured from extruded silicone rubber, Ethylene Propylene Diene Monomer (EPDM) rubber or other gasket material such as neoprene and Thermoplastic Elastomer (TPE) compatible with silicone sealant. Gaskets shall be provided on both sides of the vent glass unless it is structurally glazed. All gaskets/ weather seals/ spacers shall have continuous mechanical engagement to the framing members. Dense or wedge gaskets should be extrusions with a minimum

Shore A hardness of 70 durometer for hollow profiles and 55 durometer for solid profiles. Outdoor and indoor gaskets shall be silicone rubber, EPDM rubber or other gasket material such as neoprene and TPE compatible with silicone sealant. Wedge gasket needs to have a lock-in procedure to prevent disengagement from the metal frame. Sponge gaskets should be extrusions with a minimum Shore A hardness of 35 durometer and designed with 20% to 35% deformation in compression. Sponge gaskets can only be used as gap fillers and should not be used where the performance is relied on compression resistance. Glazing gaskets, sealant backers within glazing pockets and continuous glass spacer pads at structural sealant should be black heat cured silicone rubber.

Setting block

Setting block should be placed firmly and permanently in the frame members. Compatible sealant, setting chair or other means is needed to avoid block movement. Setting block should be dense heat cured silicone rubber, EPDM rubber or other material such as neoprene and TPE compatible with silicone sealant. Setting blocks are to support the glass for a minimum of 80% of the glass thickness and are to be minimum Shore a hardness of 80 durometer. They should have a length equivalent to 25 mm for every 1 square metre of glass area, with a minimum length of 100 mm for each setting block for glass panel of width greater than 800 mm. Setting blocks should be at equidistance from the glass centreline located at the glass quarter points. To minimise bending of the transom under dead load, the setting blocks may be moved to eighth points but should not be closer than 150 mm from the vertical glass edge nearest to the setting block. For other glass supporting cases such as bolting and point fittings, finite element analysis should be used to check the induced glass stresses. Side blocks should be located between the mid-height and top corner of the glass. Side blocks, setting blocks and chairs should be positively retained in position

TESTING AND MEASUREMENT

The following Quality control testing should be carried out by the manufacturer or supplier.

GLASS

1. Heat soak process
2. Fragmentation test
3. Surface compressive stress
4. Thickness and flatness
5. Blemish inspection
6. Boil test
7. Impact test
8. Bending test

STRUCTURAL SEALANT

Where structural sealant is proposed as structural glazing application or secondary seal of IGU, compliance certificate comprising print review report, sealant compatibility report and sealant adhesion report should be prepared.

1. Print review
2. Adhesion test
3. Compatibility test

QUALITY ASSURANCE

Quality assurance systems are required to ensure the safe use of glass in buildings. Quality assurance systems in the factory should cover all aspects from manufacturing, testing and inspection. A certificate from glass manufacturer confirming compliance to the standards is acceptable.

Tempered glass

Tempered glass is susceptible to spontaneous breakage induced by nickel sulphide inclusions. Extreme care and considerations to the occurrence of spontaneous breakage should therefore be taken in the manufacturing process of tempered glass prior to its use. Glass of suitable type, thickness and size should be selected to provide an appropriate degree of safety, taking into account the intended use and the possibility of catastrophic consequences in the event of breakage. To ensure that the tempered glass panes are of good quality, proper supervision and adequate quality control are necessary during the production of tempered glass. Tempered glass should be manufactured by a factory with the ISO 9001 quality assurance certification. Where tempered glass is used in building construction, an acceptable quality assurance scheme adopted by the glass manufacturer should be provided. The quality assurance scheme should include the following items:

1. Heat soak process to all tempered glass panes;
2. Calibration of heat soak oven and laboratory equipment for quality control tests;
3. Surface compressive stress measurement of glass;
4. Quality control procedures and requirements such as thickness measurement, flatness measurement, roller wave measurement, fragmentation test and impact test; and
5. Frequency and extent of inspection and audit by staff of the manufacturer, and Independent parties.

3. GLASS FOR EXTERNAL OPENINGS

Scope

This specification shall cover float glass, laminated and tempered, sun-guard solar control, high performance, low emissivity, vacuum deposition sputter coated glass using “Silacoat” process, to be used in windows, curtain walls, glass partitions and facades requiring conformity to acceptable international standards.

Applicable Specifications

ASTM C 1036	EN 572-2	JIS R 3202
ASTM C 1376	ASTM C 1172	EN-1096-1
ASTM C 1349	US 972	ANSI Z 97.1
ASTM E 774 Class CBA	ASTM C 1048	CPSC 16 CFR – 1201

Laminated Glazing Reference Manual of Glass Association of North America Tempering Division – Engineering Standards Manual of (GANA)

Objective

In many applications, Laminated Glass and Tempered Laminated Glass (coated and uncoated) is the logical choice for a “safety” glass, due to considerable resistance to impact, pressure, and bomb blasts, forced – entry, sound control, plus its characteristics, “Break Pattern”.

Sun guard Solar Control, high performance, low emissivity coated; Laminated Insulating Glass (Double-Glazed) is the logical choice for Energy Conservation and Sound Control. It is the objective of the specification to provide a means to demonstrate that the glass manufactured, processed, fabricated and sold by world-renowned glass manufacturers strictly adhere to the standards set by the North American and European Glass Association.

General Requirements

Submittals

1. Product Data: Submit manufacturer’s product data including performance characteristics.
2. Samples: Submit manufacturers of each type, thickness and coating.
3. Fabricator’s Certification: Submit fabricator’s certification by manufacturer.
4. Cleaning: Submit manufacturer’s cleaning instructions.

Quality Assurance

1. Manufacturer’s Qualification: Minimum 20 years’ experience in manufacturing High Performance Low emissivity vacuum deposition Sputter coated glass using “Silacoat” process.
2. Fabricator’s Qualifications: Minimum 10 years’ experience manufacturing Laminated glass, tempered glass and double-glazed glass units meeting ASTM C 1172, CPSC 16CFR-1201 and ANSI Z 97.1 standards.

4. SPECIFICATION FOR ALUMINIUM WORKS DOORS & WINDOWS

General

Aluminum glazed units shall be supplied with all hardware furniture and fittings.

The Contractor shall submit to the Engineer the shop drawings and technical data and other relevant information for approval of the Engineer.

The Contractor shall include in his rates the cost of tests generally required for ascertaining the suitability of aluminum extrusion, anodizing, strength of joints, gaskets and weather stripping, strength of joints and air water infiltration.

Materials

All selections shall be extruded from aluminium alloy 6063 T 5 temper and sections shall be designed to give rebated internal and external faces. Profile thickness should be 1.5mm and above.

Aluminum sections for mullions, frames, transoms, heads and the sills and the other members should strictly comply with the requirements laid down in the following standard. BS EN 515, Part 01 to 04 of BS EN 573, Part 01 to 09 of BS EN 755

Powder coating

Powder coated material should be manufactured using architectural grade pure polyester powder with appropriate pre – treatment. Standard coating thickness is to be 60 – 80 microns on the significant surface as per BS 1615. Powder used to coat the products shall meet GSB, Qualicoat 1.5 and Class 2 standards and British Standards for weathering, adhesion, impact etc.

Powder Coating Brand – Jotun / Axalta / DGL / AkzoNobel or equivalent

General Coating thickness 60-80 µm

Warrenty period – 25 years

Accordance with BS 6496:1984

Film Thickness (EN ISO 2360:2003) - 60 - 80 microns (Significant surface)

Impact resistance (2.5 Nm: EN ISO 6272-1:2004) - No sign of cracking Erichsen Cupping Test

(5 - 10 mm - EN ISO 1520:2001) - No sign of cracking or detachment

Bend test (3 - 12 mm - EN ISO 1519:2002) - No sign of cracking or detachment

Adhesion (EN ISO 2409:1994) - Class 0 (no detachment)

Wind Loading

The fabricated aluminum doors and windows shall be capable of withstanding a wind pressure load not less than 1500 Pascal (75M.P.H.)

Whether Stripping

The weather stripping shall be vinyl or other plastic materials which are dimensionally stable and are resistant to ultra Violet rays, water absorption and are suitable to be used in marine atmosphere.

Screws Nuts etc.

All screws, nuts, washers, bolts, rivets and other fastening devices should be of stainless steel. Aluminum alloy fasteners may be used in lieu of stainless steel fasteners with the written approval of the Engineer.

Ironmongery

Ironmongery used shall satisfactorily perform the function for which it is intended. They shall be of aluminum die cast alloy, stainless steel or other non- corrosive materials compatible with aluminum. The Engineer shall duly approve all items of ironmongery before fixing in position.

Glass

Glass shall be clear float glass suitable for single glazing and having a thickness as required (minimum 5- mm) or as specified. Glass shall conform to the relevant British Standards including following, BS 952 of 1964 – The classification of glass for glazing and terminology for work and BS 952 Part 1 of 1978.

Assembly

The design of windows should permit free movement of air from exterior environment to the immediate spaces between the window frame and ventilator to achieve pressure equalization. The windows should have snap on reusable extruded aluminum glazing beads and easily removable bottom rails. The glazing beds should not extend underneath the glass. The design of windows should permit re-glazing without disassembly all ventilator extrusions from the frame. All operable window sash corners should be mitered angle reinforced or mechanically staked and Epoxy painted. If frames with incompatible extrusions are used, then these extrusions should be mortise toned.

A permanent watertight joint should be made to the junctions of the side frame members with all horizontal members. Window panels must be provided with minimum three weep holes, one at the center and one each between the jam and the setting block. Fixing of aluminum units to concrete shall be done with high quality roll plugs with stainless steel sections and other approved fixing devices. When weather friction stays are used the shop drawings shall clearly indicate the size of such stays. The joint between window farms, external door frames and concrete or masonry work shall be adequately caulked with a suitable caulking compound. Polysulphide or high performance Silicon sealant may be used for this purpose. The Contractor shall furnish all literature and instructions published by the manufacture of the seal along with the Bid. Only caulking compound approved by the Engineer in writing shall be used.

Air and Water Infiltration

The Contractor shall submit test certificates from the manufacturer of aluminum extrusions guaranteeing that the products comply with standards applicable to the country of origin use of these materials. Fabrication and installation of aluminum units shall be thoroughly water and air tight.

Aluminum Supplier should possess the following certifications

Approved Applicator Status from the powder supplier

Qualicoat Seaside Approved Applicator

ASI Certified Supplier (Sustainable Conditions Compliance)

Accessories:

Kinlong / 3H or equivalent

Wind Load Calculation Report: Required

5. SPECIFICATIONS FOR DOOR HANDLES FOR ALUMINIUM FRAMED & TEMPERED GLASS DOORS

Type

Stainless Steel 316 mirror finished square type door handles

Manufacturer

“Dorma”, “Kinlong” or equivalent

Size to be as follows

Main entry doors to the building – 1200mm long

Entry doors to Lobbies, lift lobbies and main spaces in each floor – 800mm long

All other doors & partitions doors – 600mm long

6. SPECIFICATIONS FOR SEALANT

6.1 HIGH PERFORMANCE SILICONE SEALANT

Applications

General glazing and weather sealing in curtain wall and building facades.

Composition

One-part, neutral-cure, RTV silicone sealant

Preparation

Clean all joints, removing all foreign matter and contaminants such as grease, oil, dust, water, frost, surface dirt, old sealants or glazing compounds and protective coatings.

Application Method

Install backing material or joint filler, setting blocks, spacer shims and tapes. Mask areas adjacent to joints to ensure neat sealant lines. Primer is generally not required on non-porous surfaces, but maybe necessary for optimal sealant of certain porous surfaces. A test placement is always recommended. Apply High performance Silicone Sealant in a continuous operation using a positive pressure. (The sealant can be applied using many types of air-operated guns and most types of bulk dispensing equipment.) Before a skin forms (typically within 15~20 minutes), tool the sealant with light pressure to spread the sealant against backing material and the joint surfaces. Remove masking tape as soon as the bead is tooled.

Colour

As specified by the Architect

Approvals/ Specifications

Meets the requirements of: KS F 4910-2000 F25LM

Limitations

High performance Silicone Sealant is not approved for use as a structural sealant.

High performance Silicone Sealant should not be used:

- In below-grade applications
- When surface temperatures exceed 50°C (122°F)
- On surfaces that are continuously immersed in water
- On building materials that bleed oils, plasticizers or solvents, green or partially vulcanized rubber gaskets or tapes
- On frost-laden or wet surfaces
- In totally confined joints (the sealant requires atmospheric moisture for cure)
- If the sealant is intended to be painted (paints do not typically adhere to most silicone sealants)
- To surfaces in direct contact with food or other food-grade applications

6.2 STRUCTURAL SILICONE SEALANT

Applications

Silicone structural glazing and protective glazing applications

Composition

One-part, neutral-cure elastomeric sealant

Preparation

Clean all joints and glazing pockets, removing all foreign matter and contaminants such as grease, oil, dust, water, frost, surface dirt, old sealants, or glazing compounds and protective coatings.

Application Method

Install back-up material or joint filler, setting blocks, spacer shims, and tapes. Mask areas adjacent to joints to ensure neat sealant lines. Primer is generally not required on non-porous surfaces, but may be necessary for optimal sealing of certain porous surfaces. A test placement is always recommended.

Apply Silicone Structural Sealant in a continuous operation using a positive pressure. (The sealant can be applied using many types of air-operated guns and most types of bulk dispensing equipment.) Before a skin forms (typically within 10 minutes), tool the sealant with light pressure to spread the sealant against the backing material and joint surfaces. Remove masking tape as soon as the bead is tooled.

Colour

As specified by the Architect

Approvals/Specifications

Silicone Structural Sealant should be tested and designed to meet or exceed the test requirements of:

- Federal Specification TT-S- 001543A (COM-NBS) Class A for silicone building sealant
- Federal Specification TT-S-00230C (COM-NBS) Class A for one-component building sealant
- ASTM Specification C-920 Type S, Grade NS, Class50, Use NT, G and A
- ASTM C1184 Standard Specification for Structural Silicone Sealant
- Chinese specification GB 16776 for structural glazing
- SNJF VEC

Limitations

Silicone Structural Sealant should not be applied:

- To building materials that bleed oils, plasticizers, or solvents— materials such as impregnated wood, oil-based caulks, green or partially vulcanized rubber gaskets or tapes
- In totally confined spaces as the sealant requires atmospheric moisture for cure
- When surface temperatures exceed 60°C (140°F)
- Where painting of the sealant is required, as the paint film may crack and peel
- To surfaces in contact with food— this sealant does not comply with Federal Food and Drug Administration food-additive regulations
- In below-grade applications
- For use as an interior penetration fire stop sealing system
- In horizontal floor joints where abrasion and physical abuse are likely to be encountered
- To frost-laden or damp surfaces

- For continuous immersion in water

7. FLOOR & WALL TILES

Homogenous floor tiles.

Should be Fully Vitrified Homogeneous porcelain with high scratch hardness

Dimension & surface quality

Length & Width - 300mm x 600mm, 600mm x 600mm, 600mm x 1200mm

Deviation in Length & Width - $\pm 0.3 \%$

Thickness – Set by Manufacturer

Deviation in Thickness - $\pm 5 \%$

Straightness of Sides - $\pm 0.5 \%$ (Max 2 mm)

Rectangularity - $\pm 0.6 \%$ (Max 4 mm)

Surface flatness - ± 1.8 mm (Max)

Surface quality - Min 95 %

Physical Properties

Water Absorption by mass (Average) - $< 0.5 \%$

Modulus of Rupture- > 35 N/mm²

Abrasion Resistance (Maximum)-Deep Abrasion- Maximum 175mm³

Moh's Scale Hardness – to comply with EN 101

Slipperiness – to comply with ISO 10545.17

Colour Resistance to light – resistant

Thermal Properties

Thermal Expansion - $< 90.0 \times 10^{-7} \text{ }^{\circ}\text{C}^{-1}$

Moisture Expansion – Nil

Resistance to Thermal Shock - Min 10 Cycle

Resistance to Crazeing - Min 4 Cycle

Frost Resistance – Resistant

Chemical Properties

Chemical Resistance – resistant

Resistance to Stains - Min Class III

Laying of tiles

The contractor shall be entirely responsible for the fixing of both the external and internal tilling on both floors and walls by using proprietary tile adhesive suitable and grouting materials 'Laticrete', 'Mapei', 'Litokol' and as per the manufacturer's specifications. Shop drawings to be prepared for the desired tile pattern as per the architect's instruction. The work is to be carried out in small sections, such that the open time of the bedding mortar does not exceed five minutes. On completion of the laying of the tiles the joints shall be cleaned out and the surface of the tiles washed, ready to receive pointing mortar. Pointing mortar or the grouting color to be selected by the Engineer is to be worked into the joints. The joints are to be finished flushed or recessed as required and the face of the tiles cleaned off with fresh water recommended solutions to remove all traces of grout after the joint material has started to harden.

Expansion joints

All quarry, ceramic, glazed or glass mosaic tiles are to be laid with their base screeds in panels not exceeding 20m², and separated by expansion joints 6mm wide. All mortar is to be thoroughly raked from expansion joints so that the joints are entirely open from the surface of the tiles to the concrete structure behind. The joint is then to be filled with a foam plastic or neoprene filler, stripped to a depth of 12mm below the surface of the tiles, and neatly pointed flush with approved polyurethane mastic of approved color.

Where expansion joints are to be formed in external ceramic facing wall tiles, the joints shall be formed in accordance with the following procedures.

1. Lay backing render.
2. Lay tiles as specified leaving 6mm gap or widths as shown on drawings between 2 sections of tile at location of joint. Rake out mortar adhesive from joint down to backing render
3. Cut 3mm approximately wide joint in backing render using diamond saw.
4. Point joint flush with joint sealant color to be approved by the Architect.
5. Where joint cannot be cut with diamond saw such as in corner a timber fillet 20 x 20mm must be placed in backing render and joint formed during laying of tile and backing render.

Latex additives to External Renders, Backing & Tile bedding

All external renders, render backing coats, dubbing out and tile bedding shall have proprietary latex additives added to the mix of various layers as necessary.

Portland cement, sand and latex additives within the leveling beds, backing coats and renders shall be mixed according to the manufacturer's specification.

Cleaning

All tiles should be cleaned as the work proceeds immediately after laying by washing. If smears or effloresce cannot be removed by washing, the joints are to be thoroughly saturated with clean water and the tiles cleaned with dilute acetic acid, 1:5 or 1:6, applied for 5-10 minutes and then thoroughly washed off with running water.

Tile Skirting

Tile skirting shall be to a height of 100mm, flushed with the wall finish and a 6mm plaster groove separating tile skirting from the wall finish.

Tile Nosing

The contractor shall form the Tile nosing by pasting two tile layers to form the nosing when used in stairway treads as detailed in drawings. The contractor shall also have the option of using prefabricated Nosing tiles for this purpose with the approval of the Architect.

Remarks

Special attention shall be paid to the following points to achieve Best performance of the whole system.

1. Be sure that sufficient expansion joints are properly located in tile work, especially for fixing tile on external areas, located at storey heights horizontally and 3m to 4.5m apart vertically according to B.S. 5385 : Part 2. No external tiles shall be laid in panels exceeding 20m² without expansion joints. Expansion joints shall be placed through the tile, through the tile fixing mortar, through the leveling mortar to the concrete structure. Facade must be "allowed to move" from thermal expansion etc.
2. All materials used must be fresh and dry to avoid poor performance.
3. Never let the grout haze stay overnight.
4. Initial cleaning with clean water is necessary.
5. Back buttering of tiles is highly essential for full bedding and optimal adhesion
6. All tilling works to be protected against scratching, crazing or any other damage during and after the installation up to the handing over.

Slip Resistance on surface of floor finishes

Area / Room	Minimum slip resistance (R) on floor surface per DIN 51097
Areas where the floor always keeps dry.	Class A
Shower rooms, Bathrooms etc	Class B
Terrace etc.	Class C

8. POWER TROWEL FINISHED FLOOR

Where trowelled concrete is specified the surface of the concrete is to be trowelled smooth and flat using a steel power trowel machine, leaving the surface free from trowel or float marks. base screeds is to be done in panels not exceeding 20m² including GI mesh panel to control cracks, and separated by expansion joints 6mm wide.

Expansion joints to be filled with Self-leveling, two component Polyurethane sealant as per the manufacturer's specification.

Non-metallic floor hardener to trowelled concrete /floor screeds shall be supplied and laid by the approved specialist at the Contractor's expense.

The Contractor shall ensure that the application is in full compliance with the manufacturer's instruction and recommendation and shall be fully responsible for producing a hardened floor finish which is completely satisfactory to the Engineer.

9. MACHINE CUT CONCRETE FLOORS

- **Strength:**
The concrete should have a minimum compressive strength as specified by the Engineers Design
- **Mix Design:**
As specified by the structural Engineer in the design.
- **Slump:**
The slump test should result in a value of S4 ($\leq 210\text{mm}$ or 8.3 inches).
- **Flatness (FF):**
The finished floor must meet a Floor Flatness (FF) rating greater than 50.
- **Levelness (FL):**
The Floor Levelness (FL) specification will vary based on the project and design requirements.

Cutting Machine Specifications

- **Blade:** The blade should be a metal-bonded diamond blade, suitable for concrete cutting.
- **Cutting Depth:** Aim for a depth that is one-quarter to one-third of the concrete slab's thickness for expansion joints.
- **Machine Type:** Walk-behind saws are a common and effective machine type for this task, with blade diameters ranging from 18 to 24 inches (approx. 45-60 cm) and cutting depths from 6 to 12 inches (approx. 15-30 cm).
- **Dust Control:** A water attachment to suppress dust and a vacuum attachment to collect wet filings are essential to prevent contamination of the air and HVAC systems.

Workmanship & Technique

- **Timing:** Cuts should be made using a chequered board sequence, and a minimum of 48 hours should pass before concreting in adjacent bays to allow for initial contraction.
- **Joint Filling:** Fill the joint before or after the initial grinding passes but before any further grinding is completed.
- **Surface Preparation:** Chemical preparation of the substrate, such as acid etching, is not acceptable.
- **Substrate Conditions:** Before cutting, evaluate the existing concrete for cracks, damage, or contaminants.

Safety

- **Dust Suppression:** Ensure dust is suppressed during cutting to minimize airborne concrete dust and prevent health hazards.
- **Equipment Maintenance:** Regularly maintain and inspect all cutting equipment, including the blade, for optimal performance and safety.

10. STAMPED CONCRETE FLOORS

Description

Provide 50 mm thick concrete topping with surface hardener and anti-slip finish (Doughnut finish) to ramp surfaces.

Specification:

Ramp slab reinforcement shall be detailed with a minimum cover of 40 mm (to structural concrete).

Provide an additional concrete topping not exceeding 50 mm thick, laid monolithically or bonded to the base slab by surface roughening and cement slurry or approved bonding agent.

The topping shall be of minimum grade 30 N/mm², apply a surface hardener onto the topping surface after bleed water has evaporated.

Work in and float to achieve a dense, wear-resistant surface.

While concrete remains green, form circular grooves (“doughnut finish”) using approved roller/template, ensuring uniform anti-slip texture throughout.

The surface shall be cured in accordance to prevent dusting, scaling, or shrinkage cracks.

11. EPOXY COATING FOR THE FLOOR

This section includes the furnishing of materials and equipment and performing labor necessary to complete the installation/application of architectural concrete floor coating as shown on the Drawings and as specified herein:

Post-Contract Submittals

1. Product Data: Current edition of manufacturer's product literature including physical data, chemical resistance, surface preparation, and application instructions.
2. The Contractor shall submit manufacturer's technical information including basic materials and application instructions for each coating material specified.
3. The Contractor shall provide samples of each color and material to be applied, with texture to simulate actual conditions, on representative samples of the actual substrate. The Contractor shall resubmit samples as requested by the Engineer until the required sheen, color and texture is achieved.

Closeout Submittals

1. General: Comply with the Closeout Procedures (if any) and submit the following:
 - a) Warranties: As specified hereunder.
 - b) Operation and maintenance manuals: Include material and product details with the manufacturer's reference numbers, descriptions of materials and procedures for maintenance

Codes and Standards

1. ASTM International (ASTM) ASTM C150/C150M 19a Standard Specification for Portland Cement
2. ASTM C579-18 Standard Test Methods for Compressive Strength of Chemical-Resistant Mortars, Grouts, Monolithic Surfacing, and Polymer Concretes
3. ASTM D2047-17 Standard Test Method for Static Coefficient of Friction of Polish-Coated Flooring Surfaces as Measured by the James Machine
4. ASTM D2240-15e1 Standard Test Method for Rubber Property — Durometer Hardness
5. ASTM D2370-16 Standard Test Method for Tensile Properties of Organic Coatings
6. ASTM D4060-19 Standard Test Method for Abrasion Resistance of Organic Coatings by the Taber Abraser

Quality Assurance

1. Qualifications

- (a) The manufacturer shall have a minimum of ten (10) years' experience in the production, sales, and technical support of similar materials and products. Manufacturer is required to meet all provisions of this specification as well as provide evidence for compatibility between components to the satisfaction of the Engineer
- (b) The applicator/installer shall have a minimum of five (5) years' documented experience in the application of similar materials and products.

Mock-ups:

Apply mock-ups to verify selections made under sample submittals and to demonstrate aesthetic effects and set quality standards for materials and execution.

- (a) Apply full-thickness mock-ups on 1200 mm square floor area selected by the Engineer. Include 1200 mm length of integral cove base.
- (b) Test mock-up with anticipated chemicals to be used in the designated area.
- (c) Approved mock-ups not damaged during the testing cannot become part of the Works.
- (d) Sign-off from the Engineer on texture for slip-resistance and clean ability must be completed before commencing application of floor coating system.

Quality Benchmark

Installation First structural bay of each type of epoxy-based, resinous floor coating and floor hardener in location to be agreed with and to the acceptance of the Engineer.

Delivery, Storage and Handling

1. Packing and Shipping All materials are to be delivered to the job site in the manufacturer's original packaging. The product code and other identification marks should be clearly marked and visible.
2. Storage and Protection
 - (a) All materials shall be stored in a cool, dry place out of the direct sunlight and away from any ignition sources. The applicator should refer to the manufacturer's literature and material safety data sheets for more information on storage and protection of all materials on the job site.
 - (b) Material Safety Data Sheets (MSDS) shall be kept on the job site and made readily available for all personnel.
 - (c) Keep containers of materials sealed and ready for use.

Warranty

Provide an "extended warranty" beyond DNP joint and several warranties signed on a single document by manufacturer and installer/applicator jointly and severally warranting the materials and workmanship for a period of five (5) full years from date of the Taking-Over Certificate.

Epoxy Coating – Dust Proofing

- a) Description: Epoxy-based paint applied to locations indicated on the Drawings.
- b) Manufacturer: As approved by the Engineer.
- c) Substrate: As indicated on the Drawings.
- d) Color: As selected by the Engineer.
- e) Preparation: In accordance with the paint manufacturer's recommendations.
- f) Application: Roller, brush or spray.

Epoxy Paint Skirting

- a) Description: Epoxy paint skirting applied to locations indicated on the Drawings.
- b) Manufacturer: As approved by the Engineer.
- c) Substrate: As indicated on the Drawings.

- d) Color: As selected by the Engineer.
- e) Preparation: In accordance with the paint manufacturer's recommendations.
- f) Application: Roller, brush or spray.

Materials

Epoxy-Based Coating

Conform to the respective specification, standards and requirements specified herein.

Epoxy-based coating shall be two (2) component epoxy resins and polyamide curing agent as follows:

1. Solvent-free two (2) components colored epoxy for self-smoothing screeds or approved equal.
2. Self-smoothing floor coating: 2-3 mm layer thickness
3. Primer: Self-smoothing floor primer.
4. Color and texture: As selected by the Engineer.

Source Quality Control

Obtain primary chemical-resistant seamless epoxy-based coating materials including primers, resins, hardening agents, finish or sealing coats respectively from a single manufacturer with not less than ten (10) years of successful experience in supplying similar materials for work of type described in this section. Provide secondary materials only of type and from source recommended by manufacturer of primary material

Execution

Examination

1. Examine the areas and conditions where the floor coating system is to be installed and notify the Engineer of conditions detrimental to the proper and timely completion of the work where the detrimental conditions are attributable to the Interface Contractors. Do not proceed with the work until unsatisfactory conditions have been corrected in a manner acceptable to the Engineer.
2. The Contractor shall proceed with epoxy-based floor coating, floor hardener and resinous finish work only after substrate construction, including curbs, spill dams and equipment pads, and penetrating work through substrate has been completed. No phased construction shall be permitted by the Engineer.

Preparation

1. Patching and Joint Preparation Prior to architectural concrete floor finish coating application, the floor shall be examined for spalls, pits, holes, cracks, non-functional joints, and other defects. These defects must be treated after substrate preparation and before coating application with the suitable manufacturer- and applicator- recommended products. For functional or expansion joints, these shall be treated with 100% solids elastomeric resin having a minimum elongation of 150%.
2. Concrete Surfaces Shot-blast, diamond-grind or power-scarify as required to obtain clean, open porous concrete surface. Remove foreign materials to provide a sound surface, free

of laitance, glaze, efflorescence, and any bond-inhibiting curing compounds or formwork-releasing agents. Remove grease, oil, and other penetrating contaminants as well. Repair damaged and deteriorated concrete to acceptable condition; leave surface free of dust, dirt, laitance, and efflorescence.

Application

1. Prime Coat: Apply primer over prepared substrate at manufacturer's recommended spreading rate. Coordinate timing of primer application with application of topping mix to insure optimum adhesion between chemical-resistant epoxy-based coating materials and substrate.
2. Finish or Sealing Coat: After topping mix has cured sufficiently, apply finish or sealing coat of type required by the manufacturer to produce required finish indicated and in number of coats and spreading rate recommended by manufacturer.
3. Epoxy-based Coating
 - (a) Application
 - i. Comply with epoxy-based coating manufacturer's written instructions for installation of epoxy coating system, including surface preparation, joint treatment, flashing, reinforcement, accessory items and surfacing.
 - ii. Apply materials by methods as instructed by epoxy manufacturer to provide uniform thickness.
 - (b) Adjusting, Cleaning and Protection
 - i. Upon completion of the work, repair surfaces that have been permanently stained, marred, or otherwise damaged. Replace work that is damaged or cannot be adequately cleaned as directed.
 - ii. Upon completion of the work, remove unused materials, debris, containers and equipment from the job site. In addition to the initial cleaning procedure required, clean the work before acceptance by the Engineer.
 - iii. Protect the work during the installation period so that it will be without any indication of use or damage at the time of acceptance. Until the epoxy-based coating is fully cured and protected with a temporary covering during the construction period, keep the coating areas free from traffic and other trades. Provide necessary temporary protection to prevent damage, such as that caused by traffic, gouging, scraping, and spillage of deleterious substances, excessive heat, or other manner.

Site Quality Control

1. The Engineer reserves the right to invoke the material testing procedure at any time, and any number of times during period of architectural concrete floor coating application.
2. The Contractor shall engage service of an independent testing laboratory to sample materials being used. Samples of materials shall be taken, identified and sealed, and certified in the presence of the Engineer.

12. GRANITE FLOORING & VANITY COUNTERS

Name of the Granite Stone: Absolute Black Indian Granite

Alternative Names of Absolute Black Indian Granite:

Jet Black Granite, Nero Assoluto, Nero Assoluto India, Negro Assoluto, Granite Black Absolut, Nero Black Absolute Granite, Nero Indian Granite, Nero Indian Black Granite, Pure Black Granite, Indian Black granite, India Black Granite, Black Absolute Granite, Premium Black Granite, Granito Negro Assoluto, Black Absolute Granite, Granito Nero Assoluto Indiano, Indischer Super Black Granit, Indian Dense Black Granite, Indian Jet Black Granite, Granit Negru, Negru Granit, Supreme Black Granite, Premium Plus Black Granite, Dense Black Granite, Luna Nero Granite, Black Assoluto Granite India, Granity 'Black', Nero Absolut, Black India, Indian Black, Indisch-Schwartz, fndisch Black, Nero India, Nero Absolute (Supreme Black)

1. Absolute Black Granite Sizes & technical Specification

(1) Standard Tiles (Cut & Polished) for the floor & Walls	600 mm X 12000 mm X 20 mm thick
Required Finish	Polished/Flamed
Applications or Uses of Absolute Black Granite:	
Absolute Black Granite for Flooring, walls Vanity tops,	
Technical Specifications Absolute Black Granite:	
Compressive Strength	2777 Kg/cm ²
Comp. Strength after Gelivity	2696 Kg/cm ²
Ultimate Tensile Strength	274 Kg/cm ²
Coeff. Thermal expansion	0.0045mm/mc°
Water Absorption	0.04%
Impact Test-Min Fall Height	68 cm
Specific Gravity	2.960 Kg/m³
Hardness (Moh's Scale)	6.5

Scope of Work

This method statement outlines the procedures and quality control methods for the supply, Laying, and finishing of marble & granite works including:

- Floor Screed.
- Granite flooring.
- Granite vanity top installation.

Materials

- **Screed:**
Cement & Sand

- **Flooring:**
Natural granite slabs (as per approved sample)
Adhesive (Conmix C800)
Joint fillers (grout) compatible with granite.
- **Vanity Top:**
Natural granite slabs (as per approved sample)
Cement & Sand
Joint fillers (grout) compatible with granite.

Tools & Equipment

- Marble & Granite cutter
- Drill Machine
- Buffing/Polishing Machine
- Spirit level
- Laser level
- Plumb bob
- Right Angle Ruler
- Mixing equipment for adhesives and grouts
- Suction pads
- Measuring Tape
- Rubber Mallet Hammer
- Trowel

Methodology

Floor Screed

- The surface of the base slab shall be thoroughly cleaned.
- Before laying the screed, cement slurry shall be brushed across the surface.
- The thickness of (cement : sand ; 1:3) screed shall be as determined in the approved shop drawing.
- Screed shall be finished to a hard and dense surface.
- Screed surface shall be kept moist as per project specifications.
- All type of vehicular or foot traffic shall be prohibited on screed during setting.

Granite Flooring

5.2.1 Surface Preparation

- Check substrate for levelness and compactness.
- Clean surface of dust, oil, and loose particles.

5.2.2 Dry Laying & Setting-Out

- Granite dry-laying and labelling have been completed at the factory.
- Establish a datum level for the finished floor.
- Grid & Centre lines in each direction will be established.
- Match the Granite tiles according to the approved shop drawing

5.2.3 Fixing

- The Cleaned screed floor should be thoroughly wet.
- Adhesive mixed with water should be laid and spread evenly with approximately 5mm required thickness.
- A granite Tile should be kept over the adhesive bedding and tamped with a rubber mallet hammer to achieve the required finish level of the floor.
- A Spirit level should be used continuously to determine the horizontal level of each granite tile and carry out the level from granite tile to tile.
- This method should be repeated until entire floor is completed.
- The newly laid floor should be protected from traffic for minimum 24 hours.

5.2.4 Grouting & Cleaning

- Grouting should be done after the granite floor is dry 100%.
- Application of suitable sealant and buffing the surface with steel wool pad.
- Completed floor should be covered with polyethene and handed over to the main contractor.
- In the event of other work is been carried out in the area handed over, it should be covered with rigifoam and plywood sheet by the main contractor.

Granite skirting

Granite skirting shall be to a height of 100mm. 5mm thickness of the granite skirting shall be embedded with the wall finish while only 15mm of the granite thickness is to protrude outward from the wall finish. The granite top edge shall be finished with a chamfered edge.

Granite Vanity Top Installation

5.3.1 Surface Preparation

- Clean the concrete slab surface of dust, oil, and loose particles.

5.3.2 Setting-Out

- Establish a datum level for the finished floor.
- The finished level of the granite top, granite apron, granite nosing (bull nosed) and granite back splash should be established to the shop drawing.

5.3.3 Fixing

- Required thick cement: sand (1:3) rendering has to be carried out on an even surface level by FLG.
- A granite should be kept over the cement bedding and tamped with a rubber mallet hammer to achieve the required finish level of the floor.
- A spirit level should be used continuously to determine the horizontal and vertical level of the granite.

5.3.4 Grouting & Cleaning

- Cleaning and grouting of joints should be carried out after fixing.
- The newly laid counter should be protected from use for minimum of 24 hours.
- Completed Counter Top should be properly covered with polythene and handed over to the main contractor.
- In the event of other work is been carried out in the area handed over, it should be covered proper method by the main contractor.

Delivery, Storage And Handling Of Material

- All material shall be carefully delivered, stored, and handled in a way protected from breakage, staining and other damages.
- The materials shall be stored above ground and protected from soiling.
- The material should be delivered to site to pre-assigned storage areas.
- These materials should be identified immediately after fabrication by marks and numbers that clearly indicate the location in the building according to list.
- Extra care and precaution should be taken to ensure avoidance of damage or chipping by placing and transporting the material safely on panel edge.

Health And Safety

- The area where the granite and marble work in progress shall be barricaded.
- Personal Protective Equipment's (PPE) shall be used at all the times.
- Works have to check the stability of scaffolding prior to climb it.
- People below such areas to be made aware of possible falling items.
- Only a qualified electrician should handle electricity matters at site.
- Machines to be given only to those who are properly trained to work with them.
- All machines to be checked for any possible defects before operating.
- Site to be properly lighted when dark.

Quality Control

- All materials to be inspected upon delivery.
- Installation works to be checked at every stage for level, alignment, and finish.
- Vein matching and joint alignment strictly monitored.
- A snagging list to be prepared and addressed prior to handover.
- Upon completion of each item, it should be handed over to the main contractor.
- Main Contractor provides adequate protection if heavy loads are to be moved across the flooring.

13. PAINTING

Internal Painting

Prepare and apply 2 coats of Skim Coat, 1 Coat of Acrylic Filler and 2 coats of emulsion on internal plastered surfaces

Wall putty / joint compound for smooth plaster

Water base, Acrylic ready mix putty for interior walls.

Surface preparation

Clean the surface well. Remove all loose matter by sanding with emery paper number 100/120 and wipe off the powder with cloth or cotton waste. Apply Acrylic wall filler or exterior sealer by brush or roller. After drying, sand slightly with emery paper and wall putty/joint compound by putty knife or trowel. Deep dents should be filled in thin layers. Allow to dry for overnight and sand down with emery paper 120.if necessary carry out the same process until surface is leveled. The loose powder on the surface is to be wiped off with a cloth or cotton waste. Apply one coat of acrylic wall filler or exterior sealer prior to application of paints. Do not apply finished coat on wall putty directly. Do not use in exterior surface.

External Painting

Prepare and apply Exterior quality Emulsion paint 5 coat system (1 coat of Alkali resistant sealer, 2 coats of elastomeric crack bridging primer and 2 coats of weather resistant external paint) to an approved colour ,texture and quality to external faces of walls ,columns and beams

The painting system shall have a 5 years warranty period against, discoloration forming fungus and peeling of paints.

Surface Preparation:

1. Cleaning: Thorough removal of dirt, dust, mold, and loose paint according to standards like ISO 8501-1.
2. Repair: Filling any cracks or imperfections on the wall surface.
3. Priming: Applying a suitable primer to ensure good adhesion for subsequent coats and to seal the surface

Application Method:

1. Application Technique: Specified application methods like brushing, rolling, or spraying to ensure uniform coverage.
2. Dry Film Thickness (DFT): The total required DFT, ensuring each coat meets the thickness specification for optimal protection and durability.

Quality Control:

1. Adhesion Tests: Performing adhesion tests (e.g., ISO 4624) on pre-test panels to confirm the paint system's bonding ability.
2. Visual Inspection: Ensuring a defect-free finish with no pinholes and consistent color and sheen.

14. ALUMINIUM COMPOSITE CLADDING PANEL FAÇADE

1.0 Façade Design:

Composite panel cladding shall be so designed to meet or exceed all the specified performance criteria:

1.1 Design Wind Loading :

N/m² positive and negative

No cladding element shall sustain permanent deformation or failure under loading equivalent to 1.5 times the design pressure specified.

1.2 Deflection :

Deflection of any aluminium frame shall not exceed 1/150 of the clear span.

1.3 Thermal Movement of the façade elements:

The cladding shall be designed with provisions for noiseless contraction and expansion of component materials for temperature change, ranges from to C0 without buckling, opening of joints, undue stress on fasteners, or other detrimental effects.

1.4 Flatness of installation:

With a gloss between 5% to 90% according to Gardner Scale, the cladding surface taken individually shall not have any irregularities such as oil canning, waves, buckles and other imperfections when viewed at any position but not less than an angle of 15 degrees to the true plane of the panel, with natural lighting of incident of not less than the same angle.

2.0 Material and Finishes

Supplier reference (TRUST, DURABILITY)

The panel should be supplied by a manufacturer with more than 20 years of supply and manufacturing experience and should necessarily have in-house coating and lamination process.

2.1 Panels composition:

Aluminium composite material (ACM) should be of overall thickness of 4.0 mm, comprising of a highly mineral-filled core sandwiched between two skins of 0.5mm each in aluminium.

Mechanical Properties

Alloy: EN AW-5005 A (AlMg 1) (EN 573-3)

Temper: H22/H42 (EN 515)

Section modulus(W) 1.75 cm³/m (DIN 53293)

Rigidity (Poisson's ratio $\mu = 0.3$) E.I 0.240 kNm²/m (DIN 53293)

Tensile strength coil Rm 130 N/mm (EN 1396 : 2015 / EN 485-2 / ASTM E 8)

0.2% proof stress (EN 485-2 / ASTM E 8)	Rp0.2	□ 90 N/mm ²
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Elongation (EN 485-2 / ASTM E 8)	A50	□ 5%
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Modulus of Elasticity 70,000 N/mm² (EN 1999 1-1)

Panel weight : 7.6 kg/m²

Acoustical Properties:

Sound Absorption Factor [α_s] = 0.05 (ISO 354 / EN 20354 / ASTM C 423)

Sound Transmission Loss [R_w] = 27 dB (ISO 717-1/ ISO 140-3 / ASTM E 90)

Vibration Dampening / Loss factor [d] = 0.005 (EN ISO 6721/ DIN 53440)

Thermal Properties:

Thermal Resistance (core) [R] = 0.0039 m²K/W (EN 12667 / ASTM C 1363)

Heat Transition Coefficient [U] = 5.81 W/m²K (DIN 4108)

Temperature Resistance -50 to +80 (EN 12667)

Linear Thermal Expansion - 2.4 mm/m at a 100 degree Celsius temperature difference

Laminating Strength / Bond Integrity:

DrumPeel > 110 Nmm/mm(manufactured) 110 Nmm/mm(after 21 days emmersion) (ASTM D 1781)

Paint finish/ Coating:

The external cladding panel surface shall be coil coated on an in-house continuous line by the manufacturer, using fluoro-polymetric coating system like PVDF (Fluorocarbon) or FEVE, applied through a 'reverse roller coating' process. (EN 1999 1-1)

The standard coating shall consist of an inhibitive primer and a fluoro- polymetric colour coat. The colour coat should not be less than 70 percent of poly-vinylidene fluoride resin by weight, according to AAMA 1402, with a min total dry film thickness of 27 microns. The coated surface shall comply strictly with the 'Specification for coated coil for exterior building applications' issued by ECCA / EN 1396 (European Coil Coating Association) and AAMA 2605-15 (American Architectural Manufacturers Association) .

The finished surface shall be factory protected with a self-adhesive peel off foil with a thickness of min 70 microns, to withstand 6 months exposure to local weather condition without losing the original peel off characteristic or causing stains or other damages.

The manufacturer's continuous coil coating process should be licensed and warranted by the paint supplier which paint is being used. The paint supplier, in turn, should be licensed and warranted by the original resin supplier for PVDF and FEVE paint systems respectively.

Dry film thickness 27 microns +/- 3 microns (ECCA T1 / ASTM D 1400)

Pencil hardness / Dry film hardness HB-F (ECCA T4 / ASTM D 3363)

Reverse impact resistance / paint adhesion no removal/pass (ECCA T5 / ASTM D 3359)

T- bend / coating flexibility 2T no cracking (ECCA T7)

Abrasion > 40 liters (ECCA T16 / ASTM D 968)
Colour retention / coating colour change 10 years delta E < 5 (valid for (ECCA T3/ T13/ T22 / ASTM D 2244) 7000 hrs accel weathering)

Gloss retention 10 years > 50% retention (valid for (ECCA T2 / ASTM D 523) 7000 hrs accelerated weathering)

Chalking resistance

(ECCA T 14 / ASTM D 4214) 10 years < 8 max(colours) < 6 max(white)

CHEMICAL / ACID RESISTANCE / CORROSION (specially for applications close to sea or ocean)

Salt spray (5%) at 100F 4000 hrs < 8 blisters >7 scribe (ECCA T8 / ASTM B 117

Humidity resistance(100%) at 100F 4000 hrs no change /pass (ECCA T 25 / ASTM D 2247)

Mortar resistance no visual change (ASTM C 207)

(specially for project sites where brick and mortar is used and has a chance of splashing or spilling onto the panels)

Acid rain / SO₂-resistance no corrosion / blisters after 5 rounds of 24 hours
(ECCA T 23)

(specially for projects in highly polluted cities or industrial areas)

Solvent resistance (MEK) > 100 dr (ECCA T11)

Filiform corrosion(1000 hrs) 1/m < 2 / < 2 (ISO 4623-2)

(for open edged or scratched panels in highly corrosive environment)

Application of the coating system by means of spray coating after forming and shaping of the cladding elements shall not be permitted.

The reverse side of the cladding panel surface facing the interior side shall be in mill finish or a 3 to 5 microns polyester wash coat.

Colour/Gloss : As per standard colour charts

from approx. 5 % up to 90 % gloss according to Gardner scale.

Warranty

The panel should be covered with a minimum of 10 years manufacturer's warranty.

Fire classification:

The panel shall comply to the following fire classifications :

BS 8414-1:2015+A1:2017 (external cladding system test)-PASS

NFPA 285 (intermediate scale multi-story system test)-PASS

EN 13501-1:2018 (product fire test)- CLASS B s1 d0

ASTM E84-13a (surface burning product test) CLASS A CORECOMPOSITION /FIRE RETARDANCY

The highly mineral-filled core containing approximately 70% non-combustible filler.

Calorific value< 12.5 MJ/m² (ISO 1716

TOXICITY

The panel shall comply to EN ISO 5659-2 :2012 and have a toxicity emission level : CIT < 0.75 .
(as done under EN 13501-1 : 2007 / A1 : 2009)

CERTIFICATES

EHS (Environmental/Health/Safety)

The manufacturer shall comply with the highest standard of manufacturing, environmental, health & safety :

ISO 14001:2004 (environmental management systems)

BS OHSAS 18001:2007 (health & safety management systems) ISO 9001:2015 (quality management systems)

ISO 14025 / EN 15804 (environmental product declaration (LCA)

Paint certificates/licences

ACM manufacturer should have certifications and licences from the PVDF/FEVE resin suppliers, to the paint manufacturers and from the paint manufacturers to the paint applicator.

Fabrication

1. All cladding panels shall be factory fabricated and assembled in compliance with the manufacturer's data sheets and to the best standard of workmanship under experienced factory supervision and control.
2. All panels shall be cut and routed using equipment and tools recommended and approved by the panel manufacturer.
3. If the panel is designed with the perimeter edge/s folded and framed with extruded aluminium profile, the latter shall be fixed with aluminium blind rivets with 316 stainless steel mandrel or self-drill and tap screws to the panel with edge distance not less than 15 mm. These rivets or screws shall be spaced not more than 500 mm apart.
4. If reinforcement of the panel will be required, an extruded aluminium profile of suitable cross-section and strength shall be bonded to the reverse side of the panel using double sided adhesive tape or PU adhesive . Application of bonding systems shall be in strict conformity with the manufacturer's specification. The ends of the stiffener shall be mechanically joined to the panel sub-frame.
5. Each panel shall be marked on the reverse side for easy identification of size and location.
6. Finished panels shall be stored and transported to site in vertical position, face- to-face respectively back-to-back, with adequate protection to prevent scratches and dents.
7. The factory applied protective peel-off foil shall only be removed after the panels have been installed on site.
8. In case of perforated designs: 10 year manufacturer's perforation warranty.

Installation

1. Panels shall be stored on site in vertical position, face-to-face respectively back- to-back, with adequate protection to prevent scratches and dents.
2. Any component parts, which are observed to be defective in any way, including warped ,

bowed, dented, or broken, must not be installed. Members or parts, which have been damaged during installation or thereafter before the time of final acceptance/handover shall be removed and replaced.

3. No cutting, trimming, welding or brazing of component parts during installation in any manner that would damage the finish, decrease the strength or result in visual imperfection or failure in performance shall be executed during installation. Component parts that require alteration shall be returned to the shop for correction, and if necessary replaced with new parts.
4. Anchorage of the cladding structure to the building structure shall be by approved methods in strict compliance with the specification and approved shop and installation drawings. Supporting brackets shall be so designed as to provide three-dimensional adjustments and accurate location of cladding components.
5. All components parts shall be installed level, true to line with uniform joints and reveals. Maximum deviation for vertical member shall be 3 mm max. for a 5.20 m run and 5 mm max. for a 11.00 m run. Maximum deviation for horizontal members shall be 3 mm max. in 8.50 m run. Maximum offset from true alignment between the abutting members shall not exceed 1.0 mm. The tolerance of the width of the joints between two panels shall be maximum 2 mm.
6. Installed cladding panels shall be left protected by the factory applied peel-off foil for the maximum period of 6 months . Under no circumstances shall the peel-off foil on individual panel be partially removed and left exposed to weathering.
7. Before handing over of the completed cladding, all peel-off foil shall be removed. Panels, which were exposed to weathering without peel-off foil, shall be cleaned in accordance with manufacturer's recommendation.
8. Storage: Panels shall be stored in a covered warehouse in vertical position, face to face respectively back to back, with adequate protection to prevent scratches and dents.
9. Cleaning and Maintenance:
Twice a year cleaning of the installed panels is recommended. The surfaces should be cleaned either manually using a soft brush or by means of a high– pressure cleaner(max 50 bar) with clean water. Do NOT use any strong alkaline cleaning agents. Do NOT clean surfaces heated by sun (>40oC) as the quick drying process may causes blemishes/s

Summary-Performance criteria and corresponding technical specifications

Performance Criteria	Specifications/Parameters
Mechanical Strength	<ul style="list-style-type: none"> Alloy : EN AW-5005 A (AlMg 1) Panel thickness: 4mm (0.5mm-0.5mm) Temper : H22/H42 Section modulus(W) : 1.75 cm³/m Rigidity(Poisson's ratio $\nu = 0.3$) E.I 0.240 kNm²/m Tensile strength coil : R_m 130 N/mm 0.2% proof stress: R_{p0.2} \geq 90 N/mm² Elongation: A₅₀ \geq 5% Modulus of Elasticity: 70,000 N/mm² Laminating/peel strength >110Nmm/mm
Aesthetics	<ul style="list-style-type: none"> Dry film thickness ~ 27 micros +/- 3 microns Pencil hardness: HB-F Reverse impact resistance: no removal/pass Abrasion: >40 L Color retention: 10 years $\Delta E < 5$ Gloss retention: 10 years >50% retention Chalking: 10 years <8 max for colors and <6 max for white Salt spray : 5% at 100F: 4000 hrs <8 blisters >7 scribe Humidity resistance: 100% at 100F: 4000 hrs no change Mortar resistance: no visual change Acid rain: no corrosion/blisters after 5 rounds of 24 hrs Solvent resistance: >100 dr Filiform resistance: l/m <2 Value added services by material manufacturer
Durability	<ul style="list-style-type: none"> Alloy : EN AW-5005 A (AlMg 1) Temper : H22/H42 Temperature resistance: -50 to +80 degrees C Linear Thermal expansion: 2.4 mm/m at 100Degree C temp diff. Laminating/peel strength >110Nmm/mm Supplier's track record: at least 20 years of in-house production experience Manufacturer's Warranty: at least 10 years Value added services by material manufacturer
Functionality	<ul style="list-style-type: none"> Sound absorption factor: [α_s] = 0.05 Sound transmission loss: [R_w] = 27 dB Vibration dampening/loss factor = [d] = 0.005 Thermal resistance [R] = 0.0039 m²K/W Heat transition coefficient (U)= 5.81 W/m²K
Safety	<ul style="list-style-type: none"> Core composition: min 70% mineral content in core Calorific value: <12.5 MJ/m² Fire: System test: BS 8414-1/NFPA 285; Product test: EN 13501-1/ ASTM E84-13a

	<ul style="list-style-type: none"> • Toxicity: • 3rd party certification (online listing)
Easy to fabricate	<ul style="list-style-type: none"> • T-bend/ coating flexibility= 2T no cracking • Fabrication guidelines
Value for money	<ul style="list-style-type: none"> • Value added services by material manufacturer
Trust	<ul style="list-style-type: none"> • Supplier's track record: at least 20 years of in-house production experience • Manufacturer's warranty • Value added services by material manufacturer • ISO certifications and other 3rd party certifications for fire tests • Certificates -Resin supplier- Paint manufacturer - ACM manufacturer

WARRENTY

- The manufacturer must be able to provide a 20 year warranty on the surface finish and a 10 year warranty on the composition of the product.

SERVICE

- Services in terms of proprietary installation methods, fixing details and drawings, optimization programs, technical assistance, etc

TECHNICAL SPECIFICATIONS

Technical Properties	Standard	Units	Panel Thickness		
			3mm	4mm	6mm
Thickness of AL Cover Sheet		[mm]	0.5mm		
Areal Density		[kg/m²]	5.9	7.6	10.8
Panel Width	1000mm, 1250mm, 1500mm, 1575mm				
Mechanical Properties					
(Section Modulus W)	DIN 53293	[cm³/m]	1.25	1.75	2.75
Rigidity(Poisson's ration u=0.3) E·I	DIN 53293	[kNcm²/m]	1250	2400	5900
Alloy Grade	EN 573-3		EN AW-5005 (AlMg1),		
Temper of AL	EN 515		H24 / H44		
Elasticity Modulus of AL	EN 1999 1-1	[N/mm²]	70'000		
Tensile Strength of AL	EN 485-2	[N/mm²]	R _m ≥ 130		
0.2% Proof Stress	EN 485-2	[N/mm²]	R _{p0,2} ≥ 90		
Elongation	EN 485-2	[N/mm²]	A ₅₀ ≥ 5		
Linear Thermal Expansion	EN 1999 1-1	[%]	2,4 mm /m at 100°C		
Core: Mineral filled polymer					
Surface			Coil Coating		
Lacquering			Fluorocarbon based		
Gloss, Initial Value	EN 13523-2	[%]	30 – 80		
Pencil Hardness	EN 13523-2		HB - F		
Acoustical Properties					
Sound Absorption Factor α _s	ISO 354		0.05		
Sound Transmission R _w	ASTM E90	[dB]	STC: 30 OITC: 24		
Thermal Properties					
Thermal Resistance R	ASTM C518	[m²K/W]	0.007	0.009	0.0172
Temperature Resistance		[° C]	-50 to +80		
Fire Classification	EN 13501-1		Class B, s1, d0		
	NFPA285		Pass		

15. POWDER COATED ALUMINIUM DECORATIVE MESH FAÇADE

Powder Coated Aluminium Decorative Mesh Façade

1.5mm thick R 100 x DC 30– 11x1.5mm, approximately 30% open area, manufactured in Europe. Powder-coated to colour specified by the Architect finished with two Side L-profiles to the mesh panels.

Mesh should comply with the following mill processing standards
ASTM, UNI, AFNOR, DIN, BSI, SIS, EURO NORM

Framework

Aluminium box bar fixing to the concrete structure with Aluminium L brackets using M10 SS 316 anchor bolts, SS316 screws, and nut & bolts, Aluminum rivets, and necessary accessories.

Sample to be submitted to Architect for approval before fabrication and fixing

16. ROOF SHEETING

The specification of all steel I sections and box sections should comply with applicable B.S standards .Welding methods and welding joints should comply with applicable B. S. standards.

All roofing sheets shall be of high tensile steel coloured or as specified in the drawings and/or in the BOQ, with zinc aluminium coating done to Standard AZ 150 (AZ 200 for buildings located up to ½ km. from the sea) and with material strength to standard G 550 (minimum yield strength 550 Mpa.) with a cover width of min. 762 mm and with rib height of min. 29 mm. The ribs shall be provided with anti capillary features.

The thickness of base metal shall be of min. 0.47 mm for roofing sheets. All screws used for fixing the sheets shall be self tapping fasteners meeting AS 3566 Standard or equivalent. The brand of the sheeting materials shall be LYSAGHT, or Equivalent product meeting above standards.

17. INSULATION FOR ROOF SHEETING

Material Type:

High-density mineral wool (such as Rockwool) or a similar fibrous insulation designed for acoustic and thermal applications.

Thickness: 100mm (as specified).

Density: 50 kg/m³

Acoustic Performance

Should have Excellent sound absorption, especially for low-frequency sounds. The high-density material helps reduce sound energy, preventing sound from bouncing around the cavity.

Thermal Performance

Good thermal efficiency, reducing heat transfer for improved comfort and energy efficiency.

Fire Performance

Non-combustible, typically with an A1 fire rating and Class 1 Surface Spread of Flame, ensuring maximum fire resistance.

Reflective Component

For heat reflectivity, the insulation may be available with a facing, such as reflective foil, that creates a defined air space to reflect radiant heat effectively.

Product Considerations

Manufacturer:

Product to be purchased from a reputable manufacturers of acoustic and thermal insulation, such as [ROCKWOOL](#) or equivalent

Product Range:

high-density mineral wool designed for acoustic and thermal applications.

Facings:

tissue facings or reflective foil laminates to enhance performance.

Installation Notes

Reflective Foil:

If a reflective foil is used, the bright, reflective surface must be positioned to face the air space to be effective.

Air Spaces:

The reflective foil's performance is dependent on creating defined air spaces, so proper installation to maintain these air gaps is crucial.

Support:

Do not use the insulation slab to support fixtures or fittings; all services should be fixed back through the insulation to the structural deck.

18. TOILET SYSTEM PARTITIONS



Materials

All accessories shall be made of stainless steel grade 304 and all hardware/ fittings shall be made of anodised aluminium grade 6063-T5. Powder- coated aluminium option is available upon request. The doors, pilasters and intermediate partitions shall be 12mm thick High Pressure Laminates (HPL) compact board (or phenolic board) with chamfered edges.

HPL compact boards are manufactured from sheets of special kraft and decor papers, impregnated with thermosetting synthetic resins, fused together under heat and high pressure. HPL compact board has laminates on both sides with either matt finish or textured finish. The performance of the board is tested according to BS EN Standards and has the following rating:

- ▶ Boiling Water (EN438-7) : 8.4 (Within max. 11.5)
- ▶ Fire Rating (EN476-6/7) : Class 1 (meet min. 1)
- ▶ Impact (EN438-11): 2.8 Newton (exceed min. 2.0)
- ▶ Stain (EN438-15) : 5 (exceed min. 4)

► Scratch (EN438-2) : 4 Newton (exceed min. 2.0)

It is a natural occurrence under various climatic conditions that HPL compact boards may undergo dimensional changes of tolerance differences within $\pm 5\text{mm}$.

HPL compact boards used in our systems are certified by Singapore Environment Council with Singapore Green Label.

Doors

All doors shall be of single colour, 12mm thick HPL compact board with chamfered edge. Each will be supported by 3 Stainless Steel Hinges (4 Stainless Steel Hinges for Door width $\square 750\text{mm}$) affixed to the pilaster, completed with Stainless Steel Coat Hook and Stainless Steel Door Knob.

Pilasters

All pilasters shall be of same colour as doors, 12mm thick HPL compact board with Aluminium Door Stopper profile (incorporated with Rubber Lining to dampen noise) affixed on one vertical side and completed with Stainless Steel Thumbturn for locking doors. Colours different from doors are available upon request. The pilaster shall be anchored to the floor using Stainless Steel Adjustable Leg (base $\text{Ø}64\text{mm}$) with threaded rod for stability. The floor clearance is 150mm. BESCO™ recommends standard pilaster width to be 300mm and end pilaster width to be 150mm for maximum stability.

Intermediate Partitions

All intermediate partitions shall be of same colour as door, 12mm thick HPL compact board with Aluminium U-channel, 25mm x 16.5mm x 1.8mm (cross-section dimension, L x W x Thk), affixed at its ends (to the wall and pilaster). To improve stability of the system, BESCO™ recommends that length exceeding 1700mm to be fitted with an extra Pedestal or increase thickness to 19mm HPL compact board.

Top Rail

Heavy-duty Aluminium Top Rail Channel (natural anodised coloured), 77mm x 35mm x 1mm (cross-section dimension, W x H x Thk), shall be section fixed onto the top of the pilaster for maximum strength, stability and alignment of the system.

Accessories

Each restroom cubicle will be equipped with the following accessories:

1. Stainless Steel Door Knob of either $\text{Ø}50\text{mm}$, $\text{Ø}42\text{mm}$ or $\text{Ø}30\text{mm}$ with anti-slip groove.
2. Stainless Steel Thumbturn with occupancy indicator.
3. Stainless Steel Coat Hook with rubber stopper comes with/ without cover and allow load up to 25kg.
4. Stainless Steel Hinges with cover, adjustable from fully close to open at interval of 15° .
5. Stainless Steel Adjustable Leg with brushed finish has a working range from 105mm to 165mm.

Compartment's Dimension

The recommended restroom cubicle size:

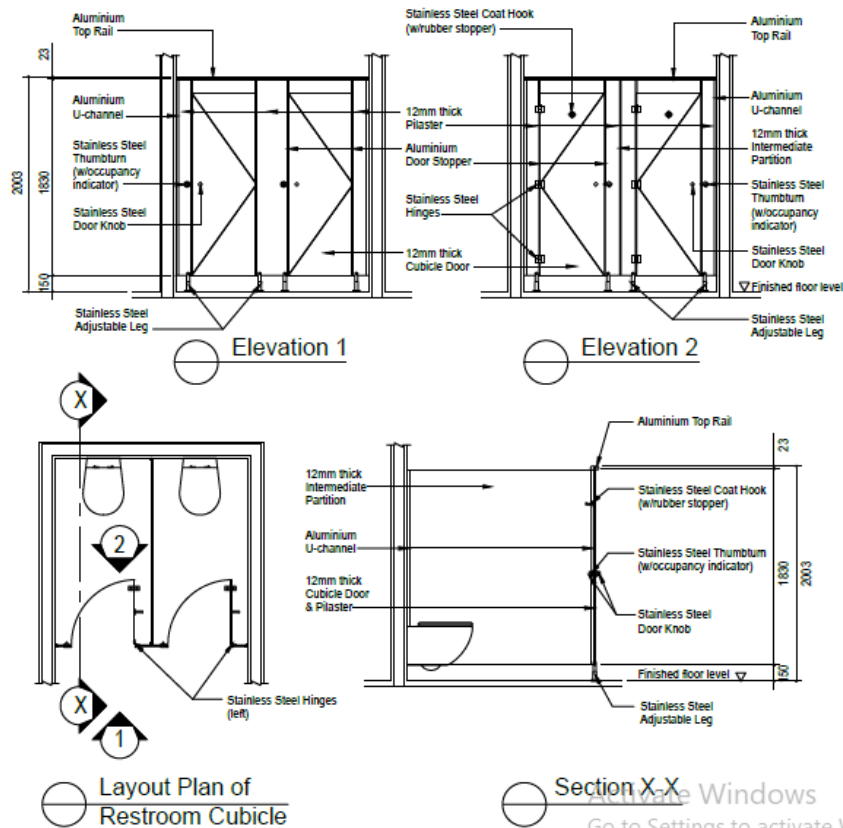
800 ~ 900 mm by 1500 ~ 1800 mm by 2003 mm (W x D x H).

1. Visible height of restroom compartment measured from top of the Top Rail is 2003 mm (inclusive floor clearance of 150 mm).
2. Door size shall be between 600 mm ~ 700 mm in width.
3. Door size shall be between 900 mm ~ 1000 mm in width for ambulant restroom.

Finishes

surface finishes, the choices of matt or glossy to the decision of the Architect.

Standard Fixing Details



19. PERFORATED METAL SHEET CEILING

Superior quality Aluminium plates with the processes of punching, forming, cleaning & washing, surface preservative treatment, spray painted with high grade polyester powder & solidifications by high temperature with the following requirements.

- Fire resistance
- Damp resistance
- Sound Absorption
- Contamination resistance
- Scrub resistance

Physical properties

Material – Aluminium

Surface – High qualified powder painting

Smoke density grade – 8

Average smoke temperature – 111c

Sound Absorption coefficient – ISO 354

Certificate standard – BS476 Part 6 1989, BS476 Part 7 1971, ASTM E84-04

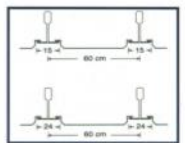
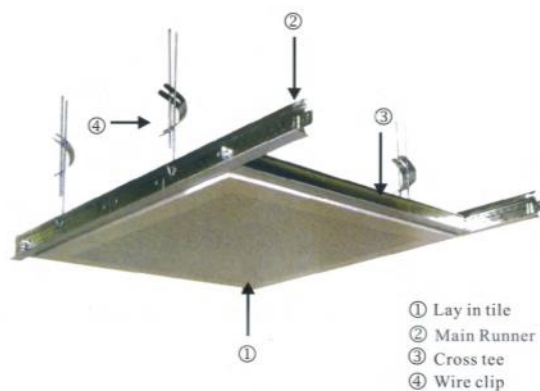
Type – Reveal edge, lay in type

Framework – GI System framework

Perforation pattern & colour – As per consultants' decision

With non-woven Acoustic black tissue inside for sound absorption.

Lay in type



20. MINERAL FIBRE CEILING

600mm x 600mm grid size reveal type suspended ceiling system, using hot dipped GI pre – engineered inter - locking main tees and cross tees and wall angles, with white baked enamel finish and suspended on 04 mm thick adjustable hanger rods with spring clips.

Ceiling panel size - 600mm x 600mm x 15mm (thickness) with a revealed edge.

Moisture content - 2% JIA A 6301

Fire Propagation test - Class 0

Flame spread - Class A (0-25) ASTM E84, Class 1 BS 476 Part 7

Light Reflectance - Over 0.80 ASTM E 1477

Sound Absorption Coefficient (NRC) - 0.55 ASTM C423

Material - mineral wool (Japan)

They have a noise reduction coefficient - (NRC) of 0.55

Class 0 Fire rating as per BS 476 (British standards)

WARRENTY







The ceiling panels should have a 10 year manufacturer's warranty

21. METAL STRIP CEILING

Supply Of 150 Mm X 3000 Mm Strip Ceiling System with GI system framework - Wall angle 24 x 24 x 3000 mm Modular carrier, 8 mm dia. threaded bar 2000 mm, 8 mm nut, Drop anchor and 150 x 3000 x 0.7 mm Aluminium strips.



Height (m/m)	width (m/m)
15	75
15	100
15	150
15	200
15 / 30	300

A shape strip ceilings accessories required	
② Panel carrier 	③ Hanger 
⑦ Main Channel 	④ Expansion screw 
⑤ Suspension bolt 	⑥ Main Channel suspension bracket 

22. PLASTER BOARD CEILING

Board Specifications

- **Board Type:** Gypsum plasterboard, a panel of gypsum core pressed between a paper or fiberglass facer and backer.
- **Thickness:** Common thicknesses for ceilings are 12mm to 13mm, but this can vary from 9mm to 15.9mm depending on performance requirements & Engineers Approval
- **Dimensions:** Standard 2400mm x 1200mm (8ft x 4ft) or 2440mm x 1220mm, 600mm x 600mm or 600mm x 1200mm.
- **Edge Profile:** Boards with square edges, suitable for applications without visible jointing, or tapered edges that allow for a recessed, smoother joint when using joint tape and compound.

Framing and Installation

- **Frame System:** Boards are to be fixed to a framing system, made of galvanized steel, using an appropriate suspension system or hangers.
- **Support Spacing:** The framing members (like furring channels or joists) must be spaced at a maximum distance of 300mm to 600mm on center, as per the chosen board's specification.
- **Screws:** Coarse thread screws should be used to fasten the board to the frame.

Finishing and Performance

- **Jointing:** Joints between boards should be finished with joint tape and joint compound to create a continuous, flat surface.
- **Acoustic Performance:** Specific types of plasterboard or mineral fiber boards can be used to provide noise reduction, with noise reduction coefficient (NRC) values often specified.
- **Fire Resistance:** Boards with enhanced fire-resistant properties, such as 12.5mm or 13mm thick fire-rated boards, are available and specified for increased fire protection.
- **Moisture Resistance:** Special moisture-resistant boards are to be used in areas like bathrooms to prevent moisture damage.

23. SPECIFICATIONS FOR PAVING

22.1 GRASS PAVING

Dimensions

Length mm 2200

Width mm 110

Height mm 80

Weight Kgs 1400

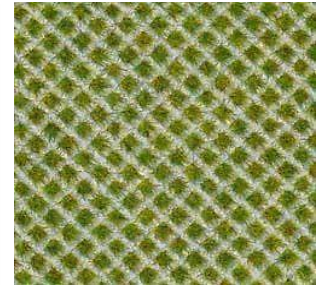
Coverage Per sq.ft 3.7

Compressive strength N/mm² 30

Colours Natural

Surface rough

Solar Reflectance Index (SRI) more than 29



22.1 RECTANGULAR INTERLOCK PAVING

Paving Block Type – rectangular interlock

Length (mm) – 100

Width (mm) – 100

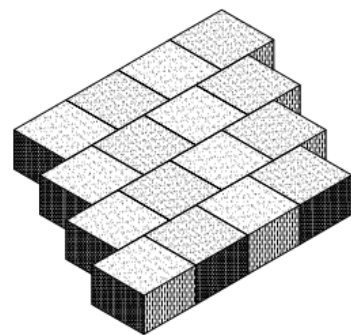
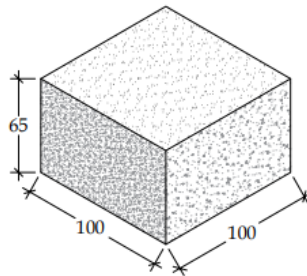
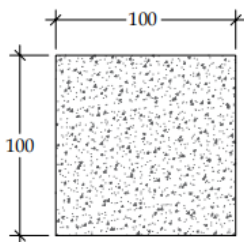
Thickness (mm) – 65

Quantity of 1 m² (Nos) – 1000

Weight per each block (kg)-Avg – 1.25/1.7

Compressive strength (N /mm²) - 15/30 /40 (To be specified by the Architect)

Colour – To be specified by the Architect



Eliana paving block
(Regular type)

24. TILTABLE ROOF

Supply of Aluminum Bioclimatic Motorized Pergola Roof structure above 8th Floor balcony outside the auditorium with the following components

- Dimensions: 2.35 m (W) x 5.0 m (L) x 2.7 m (H)
- Motor - Built in A-OK Tuya motor 220V
- Remote - 03 Nos
- Post (column): 150*150mm, thickness 2.5mm
- Beam: 250mm / thickness 2.5mm
- Blade: 140mm / thickness 1.2mm
- Tube: 65mm
- Louvered roof with LED lighting with cold and warm adjustment
- Column and cassette with RGB lighting
- Motorized Privacy Zip Screen - 8 Nos (5% fiberglass fabric)

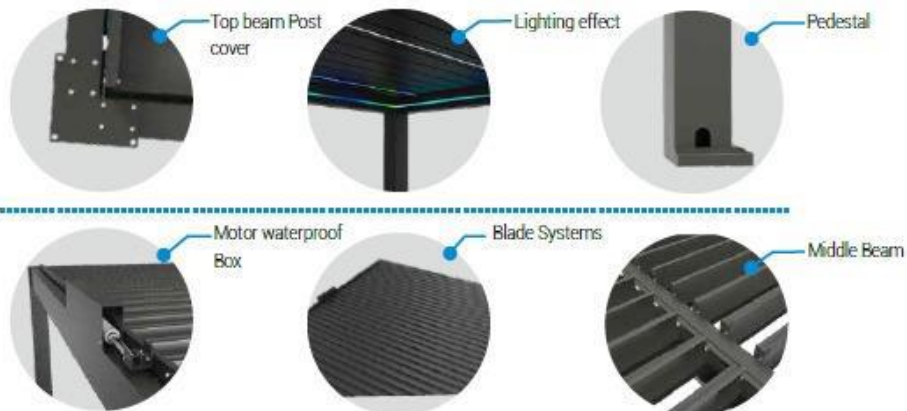


The roof should be a system roof supplied and installed from one supplier inclusive of the following characteristics

1. Components fabricated out of 6063 T5 Aluminum Alloy material
2. 100% waterproof
3. Blade rainwater diversion technology system
4. Double sink large displacement rapid drainage system
5. 6m long span load bearing design for beams
6. Implanted windproof roller blinds integrated into the design manufactured out of glass fiber fabric with Oxygen content more than 32 and B1 level fire retardant with anti-aging material zipper.



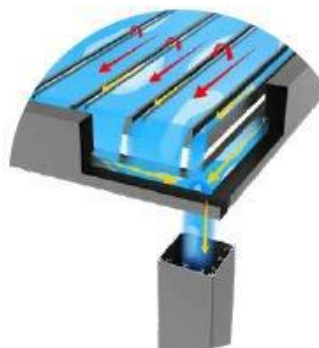
PRODUCT DETAILS



REGULER PROFILE COLOR



REGULER ZIP BLINDS FABRIC COLOR



25. GLASS & STAINLESS STEEL HANDRAILS

Key Specifications for Internal, External & Staircase handrails

1. Handrails installed must have a uniform height of 1200mm from finished floor level up to the top rail of the handrail. (Applicable for staircase, ramp handrails and balcony guardrails)
2. With regard to the top rail, the outside diameter should not be less than 1.25 inches and not greater than 2 inches.
3. The clearance space between a wall and a handrail where applicable must not be less than 1.5 inches.
4. Where ever a handrail is installed from the wall, the projection from the wall should not exceed more than 4.5 inches.

Internal guardrails & staircase handrails

Internal guardrails & staircase handrails fabricated out of S/S 316 framework finish to be stainless steel hairline finish according to the drawings, fixed with 10mm thick tempered glass panels using S/S 316 mirror finish accessories, Stud at bottom and adjustable bracket at top (Accessories to be KINLONG or equivalent as shown below). Glass standards to comply with specifications for tempered glass. The S/S uprights in the framework is to be bolted to the RCC floor using S/S 316 anchor bolts and 6mm thick S/S 316 plate. The top rail of the framework is to be mounted to the wall where necessary using S/S 316 anchor bolts and 6mm thick S/S 316 plate.

01		SS 316 mirror finish stud to fix tempered glass panel to RCC slab or staircase side. (Model : KINLONG YM03 or equivalent)
02		SS 316 mirror finish adjustable bracket to fix tempered glass panel to S/S top rail of the handrail. (Model : KINLONG ZCF03 or equivalent)

External Guardrails (Including rails on top of flower troughs, Masonry guard walls etc.)

External guardrails fabricated out of S/S 316 framework finish to be stainless steel hairline finish according to the drawings, fixed with 10mm thick but jointed tempered glass panels using S/S 316 hairline finished U” channel tacked to either side of the S/S 316 vertical posts, top rail and at the bottom of the glass. The vertical posts are to be fixed to the side of slabs using S/S 316 anchor bolts and 6mm thick S/S 316 plate. The top rail of the framework is to be mounted to the wall where necessary using S/S 316 anchor bolts and 6mm thick S/S 316 plate.

26. STAINLESS STEEL & ALUMINIUM LOUVERED CANOPY

1000mm wide Stainless steel and Aluminium canopy above Aluminium windows with Stainless steel framework fabricated out of 8mm thick s/s 316 plate fixed to the wall with s/s 316 anchor bolts using 10mm thick s/s 316 " L brackets " welded to the frame and Aluminium elliptical louvers (100x 25mm) fixed at 50mm cc to stainless steel framework as per the detail drawings and specifications.

Frame work

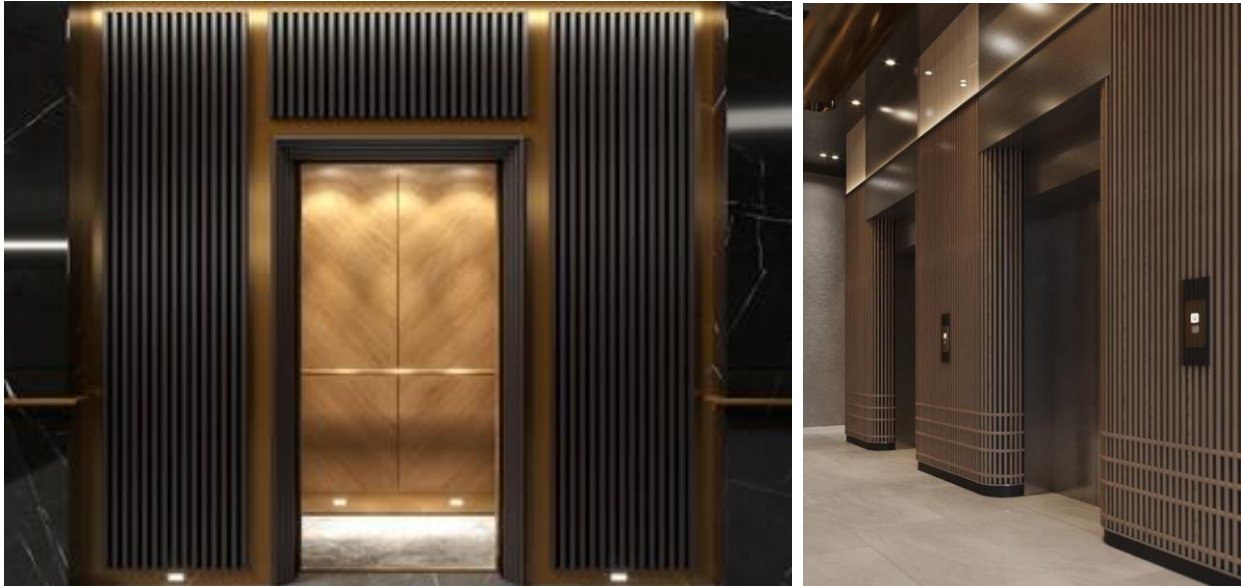
1000 mm long wedge shaped main supports Fabricated out of 8mm thick S/S 316 plate of hairline finish. Fixed to the wall using 10mm thick S/S 316 welded "L" Brackets hairline finish using 100mm long anchor bolts.

Aluminium Elliptical louvers

100 mm x 25mm Elliptical Aluminium sun louvers powder coated according to colour specified by the Architect, fixed to the SS main framework using Aluminium powder coated bracket with self-tapping screws.



27. FLUTED METAL WALL PANEL FOR LIFT LOBBY WALL FACADE



Product

Galvanized steel sheet wall paneling, protected by a high-performance, laboratory-proven paint system (Timber finish) or as specified by the Architect

Standard length 12 ft (3658 mm)

Height (covered) 16 in (367 mm)

Thickness (depth) 1 in (25.4 mm)

Weight (per sq.ft.) 0.8 lb per sq.ft. (0.36 kg)

Gauge | Galvanized Z275 (G90) 33 SS (230) grade steel as per ASTM A653/A653M

Installation orientation Vertical

Certificates

Wind Resistance

Resistance to overload due to uniformly distributed static pressure-related winds, according to ASTM STANDARD D5206-06a.

Fire Resistance

- Tested as per CAN/ULC-S135 for use in non-combustible constructions.
- Tested as per ASTM E84 for non-combustible construction (Class A category).
- Classified 0 Flammability Hazard, according to the NFPA Rating Explanation Guide.

Installation Surfaces

- On plywood (min. thickness 5/8 in)
- On wood furring (16 in [406 mm] or 24 in [609 mm] center/center)
- On metal furring (16 in [406 mm] or 24 in [609 mm] center/center)

Note: All furring strips must be level horizontally and vertically to permit installation according to accepted practice and to obtain a good final installation result.

Assembly

- Join panels across their widths by using clips to cover and protect the screw holes.

Fixation

1. Drip flashing must be installed behind the furring and weather-stripping for Fluted Panels. It must be carefully levelled, as it will determine the straightness of the work.
2. Before beginning installation, refer to the installation guides to make sure you have all the tools and accessories you need to get started.
3. A methodical check of the work should be carried out approximately every 5 sheets to detect any possible anomalies.
4. Continuously install drip mouldings, starter mouldings, inside/outside corner pieces, borders, soffits and mouldings adjacent to doors and windows in accordance with the manufacturer's recommendations.
5. Screw every 16" (406 mm) or 24" (609 mm) to the center of the holes (openings) provided.
6. If the wall exceeds 13', it is recommend to use a vertical transition moulding to support the material.
7. When several floors are to be covered, it's essential to use a horizontal transition moulding on the structure at every floor to help the building withstand the material's expansion.
8. Where necessary, cut panels to length, using only sheet metal shears or a steel nibbler.

Fastening

1. The screws used to screw our products must meet the STM B-117 2000h standard.
2. Use the Self-drilling 1 1/4- or 2 1/2-in wood screws depending on the type of furring or surface to be fastened.
3. The screws should be set with moderate contact on the clip part of the panel to avoid impeding the expansion of the metal.
4. The screws must not exert any upward or downward pressure to avoid deforming the siding or opening the panels at the joints.
5. Remove the protective film from the siding prior to installation to facilitate a good Visual inspection of the quality of the installation and in order to make appropriate Corrections as installation progresses.

Accessories & Moldings

All Accessories and moldings necessary to complete the installation of the wall panels should be compatible with the wall paneling system used.

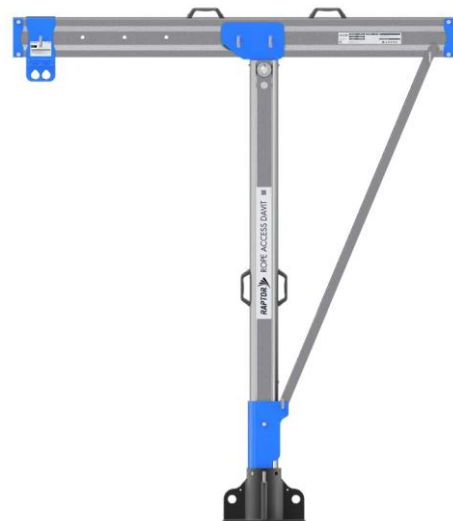
28. BUILDING MAINTENANCE SYSTEM – DAVIT SYSTEM



Industrial use, aluminum construction system with rescue and adjustable rigging anchor for access over non load-bearing areas for window cleaning and facade maintenance. System design, supply, layout, installation and certification as per the manufacturer's installation instructions and current standards.

Main features to include

1. Adjustable boom anchor
The anchor is designed to be positioned anywhere along the boom, providing flexibility for the operator.
2. High strength construction
Manufactured from high grade structural aluminium and powder coated stainless steel.
3. Easy use locking pins
Providing secure connection of the systems assembly.
4. Multiple configurations
Available in many heights and reaches to suit all facade requirements.
5. Carry handles
For aid in assembly and transport.
6. Mounting options
Designed to work with many different davit bases including floor, wall and cast in options.



Materials

- Arm and mast: manufactured from high grade structural aluminum.
- Connection brackets, end caps, supports: powder coated stainless steel.
- Davit base: G350 grade steel, galvanized finish.

Dimensions

As per manufacturers specifications & Site conditions

Substructure requirements

- Minimum concrete thickness
 - Adhesive fix: 200mm – 220mm (as per manufacturers' specifications)
 - low profile : 190mm
 - Cast-in cage bolt kit: 200mm
 - Flush mount cast-in base: 300mm
 - Minimum concrete strength: minimum 32 mPa
 - Concrete may need to be verified by engineer regarding reaction loads
 - Minimum 250mm edge distance
- Mounting method is to be decided according to site conditions & manufacturers specifications

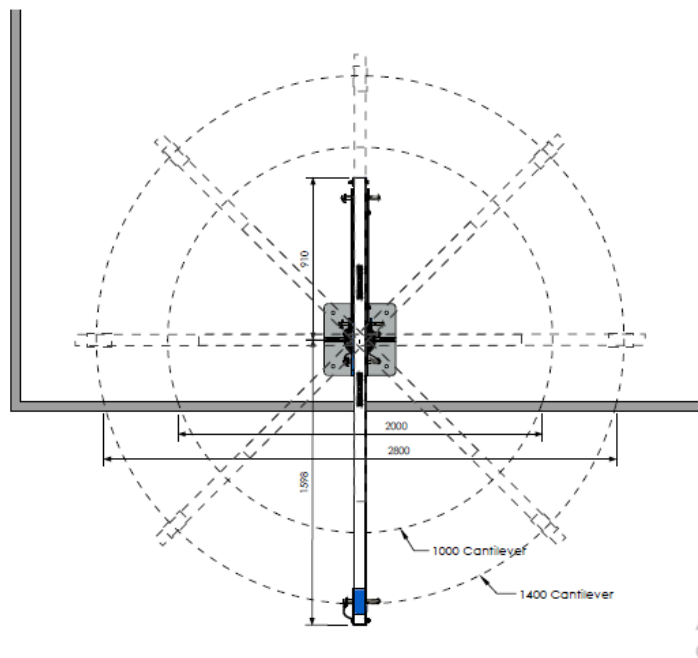
Fixings – to be done according to manufacturer's specifications

Rating

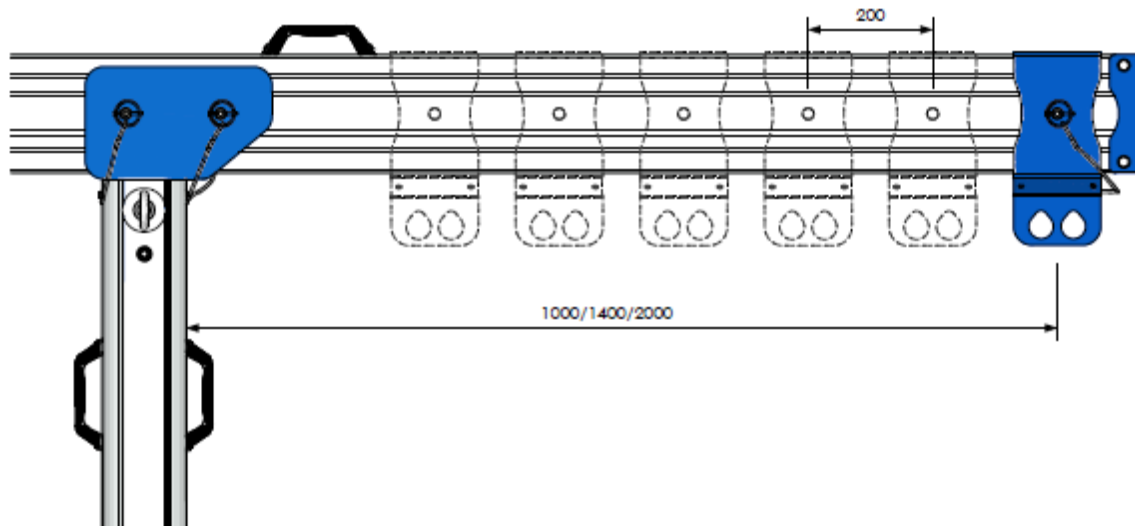
- 12kN single person use + rescue
- 400kg safe working load

Davit Operational range

The davit should be able to rotate and operate 360°, with provision for locking at increments based on site conditions. The operating range of the davit should suite the site conditions enabling maximum access to building facades using the davit.



The rigging anchor ultimate load is 12 kN at 1400mm/2000mm. The rigging anchor should be able to be positioned at 200mm increments (or as specified by the manufacturer) with a maximum outreach of 2000mm. Locking pin to be inserted once rigging anchor in final location.



Compliance

Conform with requirements of the Australian & New Zealand Standards AS/NZS 5532:2013 AS/NZS/ISO22846, AS/NZS1891 and relevant codes of practices and guidelines.

Testing

Testing and performance based on requirements of Australian Standard AS/NZS 1891 and AS/NZS 5532.

- Dynamic load test: 15kN
- Static load test: 12kN

Product warranty

10 years from date of purchase subject to correct installation.

Inspection and maintenance

Inspection and certification required every 12 months by competent person in accordance with manufacturer's specifications and requirements of Australian Standards AS/ NZS 1891 and AS/NZS 5532.

STRUCTURAL SPECIAL SPECIFICATIONS

1. General
2. Reinforced Concrete Construction
3. Earthworks / Dewatering
4. Foundations
5. Water proofing
6. Block Work / Brick Work
7. Manholes, Sumps and Water Tanks
8. Corrosion Protection
9. Structural Steelwork
10. Chases and Holes
11. Rectification of defects

1. GENERAL

A1. Structural drawings shall be read in conjunction with all other drawings and the specification in particular. Requirements for penetrations for services through structural elements shall be ascertained from mechanical and electrical drawings.

A2. SETTING OUT

For main setting out lines and levels, refer to architectural drawings. All dimensions are in millimeters. All structural members are central to grid lines unless shown otherwise. All dimensions and conditions must be verified on site and any discrepancies shall be brought to the attention of the engineer before proceeding with the portion of work involved.

A3. ABBREVIATIONS

SFL	= STRUCTURAL FLOOR LEVEL
NF	= NEAR FACE
FF	= FAR FACE
EF	= EACH FACE
B	= BOTTOM
T	= TOP
BW	= BOTH WAYS
UNO	= UNLESS NOTED OTHERWISE
SOP	= SETTING OUT POINT
EJ	= EXPANSION JOINT
MUL	= MAKE-UP LEVEL
TOC	= TOP OF CONCRETE
TBC	= TO BE CONFIRMED
EGL	= EXISTING GROUND LEVEL
FFL	= FINISHED FLOOR LEVEL
FGL	= FINISHED GROUND LEVEL
IJ	= INDUCED JOINT
LJ	= LONGITUDINAL JOINT
TOE	= TOP OF FOUNDATION
TOS	= TOP OF STEEL
CJ	= CONSTRUCTION JOINT
TOPC	= TOP OF PILECAP
TPL	= TOP OF PRECAST LEVEL
EXSSL	= EXISTING STRUCTURAL SLAB LEVEL
AP	= ALTERNATIVELY PLACED
AS	= ALTERNATIVELY STAGGERED

A4. The contractor shall submit builders work drawings showing all requirements for services, penetrations etc. For the engineer's approval. Modifications necessitated by detailed plant information shall be subject to the engineers' approval. The approval period shall be two weeks.

A5. The contractor shall submit record drawings of the as built works for the engineer's approval.

A6. Alternative designs of elements of the structure undertaken by the contractor shall be submitted to the engineer for approval.

A7. The contractor shall provide temporary bracing and shoring against lateral forces and all construction loads throughout the construction process.

A8. LEVELS

SITE DATUM = Refer to the Topographic Drawings

A9. The contractor shall be responsible for the design of all temporary works related to the construction process. The contractor shall obtain third party verification of temporary works proposals by suitably qualified professionals and shall submit evidence to demonstrate this prior to any temporary works installation. In addition the contractor shall provide a temporary works coordinator on site with the specific responsibility for the adequacy of all temporary works proposals.

2. REINFORCED CONCRETE CONSTRUCTION

B1. CONCRETE

Grade of Concrete are as follows

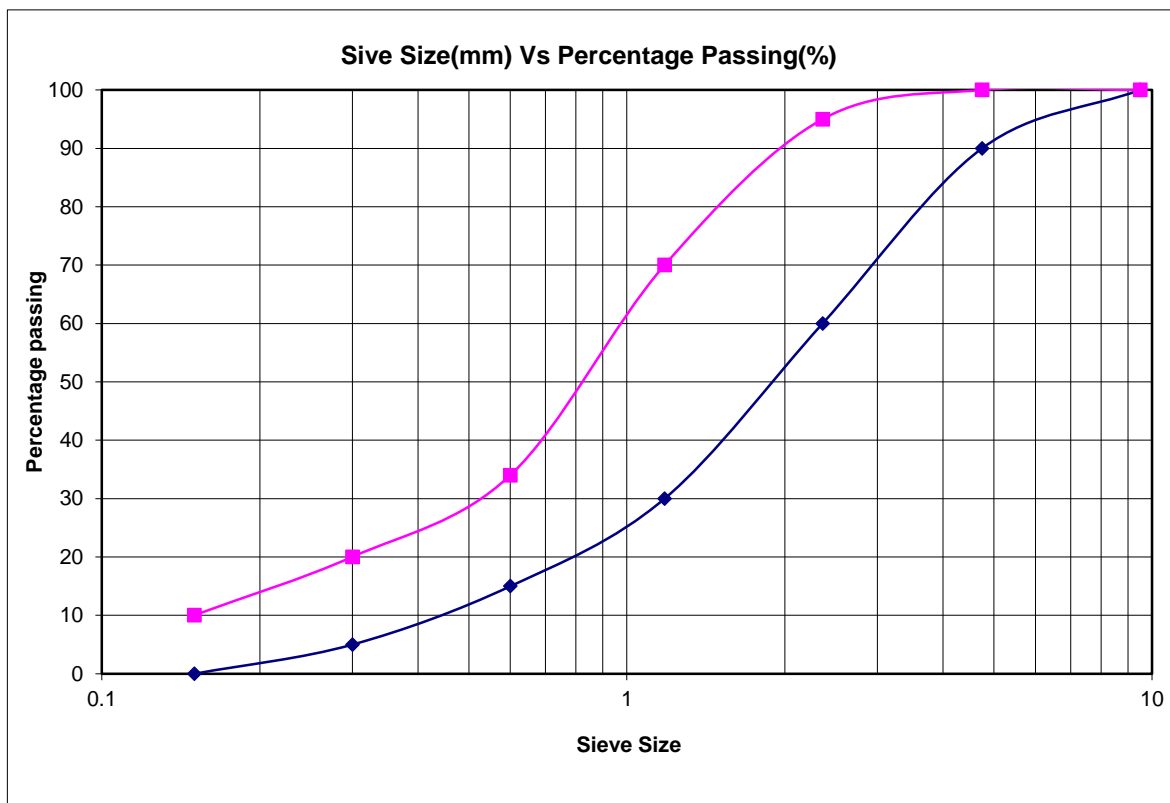
Screed Concrete	- Gr.15
Foundation & Ground Beams	- Gr.30
Column	- Gr.50 & Gr.30
Raft Slab	- Gr.30
Slabs And Beams	- Gr.30
Stair Case	- Gr.30
Water Sump & Swimming Pool	- Gr.30

The concrete mix designs for each grade should be submitted by the contractor for the approvals of the structural Engineer well in advance. Upon the receipt of approvals, the trial mixtures should be performed by the contractor or the concrete supplier to verify the mix designs . The grading for fine and course aggregates should be within the following grading curves.

Grading Requirements for Fine Aggregate BS 882:1973

Grading Zone - 1

Sieve Size (mm)	Percentage by Wt. Passing Sieve	
	Lower Limit	Upper Limit
9.5	100	100
4.75	90	100
2.36	60	95
1.18	30	70
0.6	15	34
0.3	5	20
0.15	0	10

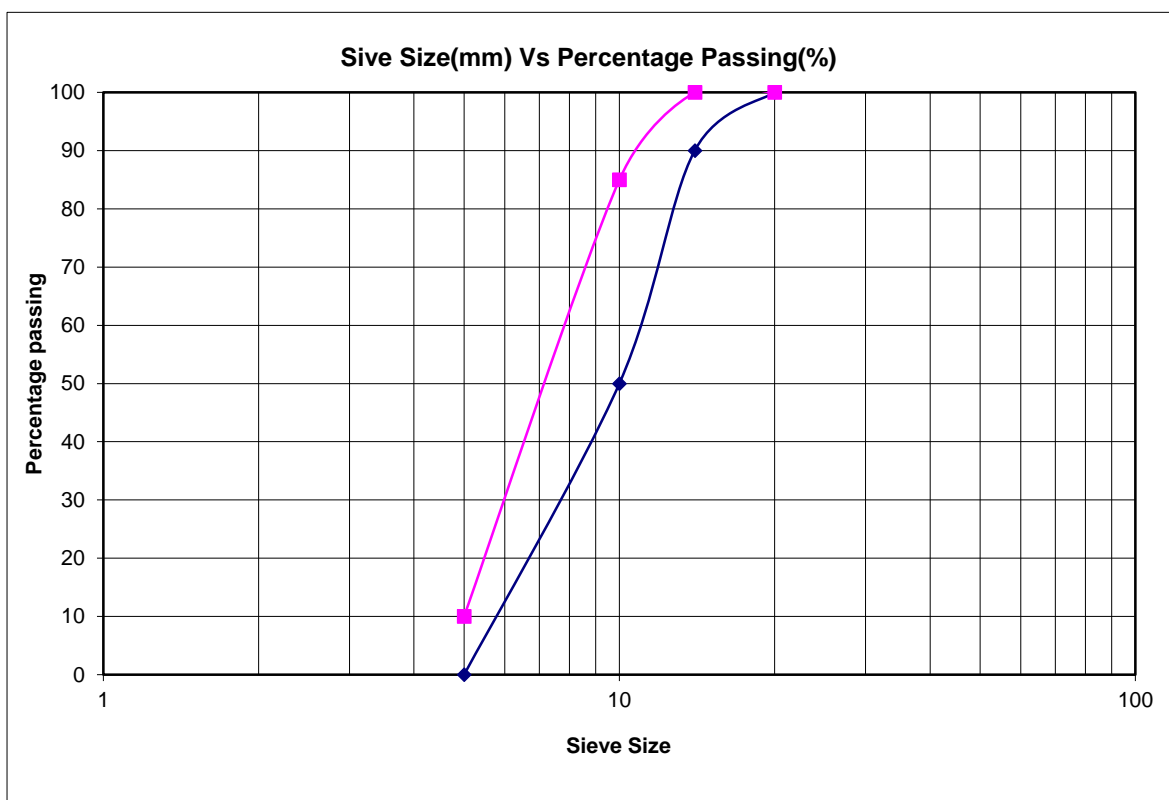


Grading Requirements for Coarse Aggregate

BS 882:1973

14 to 5 mm Aggregate

Sieve Size (mm)	Percentage by Wt. Passing Sieve	
	Lower Limit	Upper Limit
20.00	100	100
14.00	90	100
10.00	50	85
5.00	0	10



B2. REINFORCEMENT

Reinforcement shall be high yield strength deformed (yield stress $>460 \text{ N/mm}^2$) marked 'T'. The contractor shall provide detailed drawings and schedules of the reinforcement for the engineer's approval, in accordance with the specification. Chairs, spacers etc., shall be provided as necessary, to the approval of the engineer. Laps to be minimum 50 diameter unless noted otherwise. Where epoxy coated bars are used laps and anchorage's to be increased by 15% Reinforcement details shown are indicative for the preparation of the contractor's working drawings.

The contractor may replace starter bars for beams, shear walls and columns with mechanical couplers to the approval of the engineer. Preferable to use 12m bars wherever possible.

B3. COVER TO REINFORCEMENT

Cover to all reinforcement shall be as follows unless shown otherwise:-

Foundation, Column Stubs & Ground Beams	= 50mm. Surfaces cast against Ground, 40mm Other faces / on blinding
Ground Slabs	= 35mm. Top Face, 40mm Earth Face
Suspended Slabs	= 25mm. (Internal), 25mm (External)
Beams & Lintels	= 30mm. (Internal), 30mm (External)
Columns	= 50mm Surfaces cast against Ground, 30mm. (Internal, External & Surfaces in contact with Ground cast against Shutter),
Pool & Sump Walls	= 40mm Surfaces cast against Ground, 30mm. (Internal, External & Surfaces in contact with Ground cast against Shutter),

External relates to concrete faces exposed to external environment.

NOTE:- The above mentioned are the clear cover requirements to nearest Reinforcement to concrete surface (Stirrups & links in case of beams & columns respectively).

EXPOSED EDGES

B4. All exposed edges of concrete shall have a 25mmx25mm chamfer which is not shown on drawings for clarity.

B5. JOINT FILLER

Joint filler to be polyethylene compressible filler board U.N.O.

Joint sealant is to be multi component low modullus, high performance sealant, formulated from epoxy terminated polyurethane joint filler to be compatible with the selected joint sealant. All materials shall be subject to the approval of the engineer.
All applications are to be carried out strictly in accordance with the manufacturer's instruction.

B6. FINISHES

Unformed surfaces shall receive the following
Finish types as defined in the specification.
Slabs (To Receive Screed) (Light Tamped)
Slabs without Screed (Power Float)

All areas to receive a power floated or brushed finish shall have an approved surface hardener and dust inhibitor applied unless the consultant approves otherwise.
The sizes and positions of holes for services are indicative only and shall be confirmed by the contractor for the inclusion in the detailed shop drawings. All whole positions shall be approved by the engineer.

3. EARTHWORKS / DEWATERING:

C1. The contractor shall take full account of the soil investigation information and his own experience to design the necessary temporary works. The design together with the shop drawings shall be submitted for the engineer's approval prior to dewatering. All backfilling shall be compacted to at least 95% of the maximum density and in accordance with the specifications.

C2. It shall remain the contractor's obligation to provide dry working conditions. Excavation shall be at all times carried out in dry conditions. Ground water shall be maintained at least 500mm below the deepest point in the excavation while it remains open. The dewatering system used shall not affect the existing adjacent buildings in any way.

C3. Dewatering shall not be discontinued without the written approval of the engineer.

4. FOUNDATIONS

End bearing of the soil is assumed to be 100-150 kN/m² at 3.5 m below the existing ground level (E.G.L) and to be confirmed by the structural engineer after excavation

5. WATER PROOFING

SCOPE

Supply and install Membranes and Screeds including but not limited to:

- Preparation of surfaces to receive membranes.
- Membranes either over or under screeds.
- Protective screeds to fall and be laid over membranes.
- Granolithic screeds.
- Flashings, sealants, etc. to above items.

RELATED WORK

Co-ordinate and co-operate with tradesmen performing:

- Penetrations through membranes.
- Connections to drain outlets.
- Interface with other materials.

QUALITY ASSURANCE

- Suppliers and installers are required to be widely experienced in the class of work required by this Specification.
- Provide to the Engineer, evidence of current approval by manufacturer or installers of material be installed.
- Provide evidence of similar work on major projects. Provide names and addresses of work to facilitate inspection and approval of qualifications.

REFERENCES

Standards and Codes

Comply with applicable portions of the following Standards.

Unless otherwise specified, materials shall conform to current Australian Standards. Materials and workmanship shall also comply with the Building Code of Australia. Where not available, the relevant British or U.S.A. Standards shall be used:

- AS 1145 - Determination of plastic properties of plastic materials
- AS 1321 - Methods for sampling and testing adhesives
- AS 1526 - One-part polysulphide-based sealing compounds for the building industry
- AS 1527 - Two-part polysulphide-based sealing compounds for the building industry
- AS 1884 (Appendix A) - Dryness tests for concrete surfaces
- AS/NZS 2179 - Specifications for rainwater goods, accessories and fasteners.
- AS 2180 - Metal rainwater goods – selection and installation.
- AS 2433 - Plastics – method for exposure to ultraviolet lamps
- AS 2341 - Methods of testing bitumen and related road making products

AS2 700 - Colour standards for general purposes.
AS 3715 - Metal finishing thermoset powder coatings for Architectural applications
AS/NZS4200.1&2 - Pliable building membranes and underlays. Materials Installation
AS 4201 - Pliable building membranes and under-lays Test Methods
AS CA55 - Code for the design and installation of bituminous fabric roofing
AS A99 - Bituminous felt roofing
BS 6229(1982) - Code of practice for flat roofs with continuously Supported coverings.
BS 8217 (1994) - Code of Practice for built-up-felt roofing.
BS 3712 - Building and construction sealants
BS 4254 (1983) - Specification for two-part polysulphide-based sealants
BS 5215 (1986) - Specification for one-part gun grade poly sulphide-Based sealants
BS 5889 (1989) - Specification for one part gun grade silicone Based sealants
BS 6213 (1982) - Guide to selection of constructional sealants

DATA SUBMISSIONS

Prior to the commencement of the installation of the waterproofing membranes, the Contractor shall provide the Engineer with:

1. Certification from both Contractor and the Waterproof Membrane Manufacturer that the waterproofing systems together with the details and fitments are fit for purpose for the waterproofing works shown on the Drawings and specified and that they conform to the requirements of this Specification.
2. Manufacturer's data: The manufacturer's published product data including technical specifications, recommendations for installation and type test or factory test data.
3. Approval of Specialist Supplier & Specialist Applicator: The manufacturer's written approval of the Specialist Supplier & Specialist Applicator.
4. The proposed method for controlling the correct application rate of liquid applied membranes.
5. The proposed method for check – testing the thickness of completed liquid applied membranes.

CONTRACTOR'S DOCUMENTS

The waterproofing details shown on the Drawings are indicative only.

Shop drawings: The Contractor shall, in conjunction with the manufacturer Submit shop drawings, fully detailing the work and its installation. Shop Drawings shall include the various details for penetrations conditions including, but not limited to:

- Margins
- Flashings
- Movement Joints
- Capping
- Penetrations
- Outlets

SAMPLES

Prior to the commencement of work, samples of each system shall be provided, for approval of the Engineer. The samples shall be of the same materials and details as proposed for the work, including, but not limited to:

- Membranes
- Lapped joints
- Mitre joints
- Typical finishing and sealing to the extremities of the membrane.
- Movement joints
- Over-flashings
- Protective Layers
- Insulation
- Typical finishing and sealing to wastes and other outlets
- Sheet drains

SAMPLE INSTALLATION ON SITE

Install in positions in the works where directed by the Engineer sample areas of each type of waterproofing system, 10m² minimum, complete with jointing, sealing, flashing and ancillary work to demonstrate the finished works. Approved sample installations shall be permitted to be incorporated into the works, otherwise remove on completion.

MAINTENANCE MANUAL

Submit to the Engineer a manual of recommendations from the manufacturers and/or installers, for the maintenance of the waterproofing systems including but not limited to frequency of inspection, cleaning and repair.

DELIVERY, HANDLING AND STORAGE

Delivery and Storage: Materials are to be properly packaged according to the manufacture's specifications and brought to the site in original, unopened containers with grade, type and quality indicated on the labels.

SURFACE PREPARATION

Concrete or block work, whether plastered or not, shall be well cleaned and free from damp, laitance, dust and dirt; if contaminated by oil or grease of whatever nature, the patches shall be chiselled away.

Uneven areas, rough areas and chiselled patches to be treated with an approved epoxy-resin based un-pigmented primer, and to be levelled with a homogeneously mixed approved 2-component epoxy-mortar, applied while the primer is not fully hardened (wet-in-wet-method).

The smoothness and evenness of the surfaces of concrete or brick work to which the water proofing system is to be applied shall be to the entire satisfaction of the Engineer.

The primer shall be a cement paste (cement + water + resin dispersion) applied as a grouting for key of the mortar. The mortar shall consist of cement + sand + resin dispersion. The compressive strength of the fully hardened mortar shall not be less than 60 N/mm².

Both primer and mortar shall be of an approved make and be mixed and applied in strict accordance with the manufacturer's instructions.

The mortar to be finished smooth and straight using steel floats in a rotating movement and under even pressure, with rounded or covered fillets/edges as the position or purpose dictates.

WARRANTIES

The Contractor shall provide, warranties (including warranties from its Specialist Supplier & Specialist Applicator), for the supply, manufacture and installation of the waterproof membranes, their associated elements and the waterproofness of the installation.

The Contractor shall carry out the work in a manner, which ensures that the warranties of its subcontractors are not restricted or voided.

The warranty provided by this Clause shall commence on the Date of Practical Completion of the Project and shall continue for a period of TEN (10) years.

6. BLOCK WORK / BRICK WORK

Blocks shall have a minimum characteristic strength of 7 N/mm² generally and 10.5 N/mm² for load bearing walls U.N.O. All block work shall be constructed with hollow blocks uno. Brick samples should be approved by engineer.

7. MANHOLES, SUMPS AND WATER TANKS

Refer typical drawings for water proofing details

8. CORROSION PROTECTION

G1. PAINTING OF EXPOSED STEEL (PERMANENT WORK)

Surface preparation shall be in accordance with specification.

After blast cleaning, steel work shall receive a first shop coat of blast primer applied overall by airless spray, dry film thickness 20 microns minimum. After fabrication, all welded areas shall be blasted to remove weld, slag, flux splatter etc. And any loose paint. Any areas of handling damage shall be thoroughly wire brushed to remove any rust and loose paint back to a firm edge. These areas shall be made good with a metal primer to 20 microns dry film thickness.

G2. BASE PLATES

These shall be leveled using suitably sized steel shims not less than 6mm. Thk. Such packs are to be shown on the shop drawings and provided in sufficient number to accommodate variations in concrete founding level. Packs shall be sawn and not sheared or flame cut. They shall be positioned so as not to protrude outside the base plate, and be grouted in so that they are totally covered by the grout. Bolt pockets shall be thoroughly cleaned and blown out before grouting grout shall be free-flowing and non-shrink and shall fill the entire void beneath the plate. Formers shall be used, grout offset from each edge of the base plate by 20-30mm.

Overcoating system shall be as per the site condition.

G3. INTERIOR

All Steel Work : Surface Preparation Blast Clean To Sa 2½
Primer 20 Microns As (J1)
: Paint Shop Applied 80microns Of High Build
Zinc Phosphate Epoxy Primer + Site
Applied 60 Microns of Alkyd Finishes

G4. EXTERIOR

Surface Preparation ----- : Blast Clean to Sa 2½
Primer 20 Microns As (J1)
Shop Applied ----- : 80microns Zinc Rich Epoxy Primer And 200microns
High Build Epoxy Mio (On Two Coats)
60microns Of Recoatable Polyurethane Finish.

9. STRUCTURAL STEELWORK

H1. All structural steelworks shall be in accordance with bs 5950 and bs en 10025 or bs en 10210 part1.

The particular quality grade for each element shall be as follows:

S275JR For Material of Thickness < 20mm.

S275JO For Material of Thickness >20mm, <40mm.

S275J2G3 For Material of Thickness >40mm, <90mm.

S275JOH For Hollow Sections Thickness <40mm.

H2. All steel work connections, including typical connections detailed on the drawings, shall be designed by the contractor in accordance with bs 5950. Bolted connections shall, unless noted otherwise, utilize grade 8.8 bolts to BS 3692 or BS 4190, minimum diameter 12mm, with a minimum of four bolts per connection.

Bolts of diameter 30mm or greater shall be high strength friction grip in accordance with BS 4395 Part 1.

H3. Unless noted otherwise, all fillet welds shall be a minimum 6mm leg length and all butt welds shall be full penetration. Testing of welds shall be in accordance with the specification. Weld symbols are to BS 499. All welds shall be full profile, unless noted otherwise.

H4. All structural steelworks shall be corrosion protected in accordance with the specification.

H5. Members which are concrete encased are denoted

Thus: 305x165UB 31 (Cased) [Example]

These elements remain unpainted and shall be free from oil, grease, dirt, sand, loose rust and mill scale.

H6. All tubular members shall, unless noted otherwise, be sealed at each end with a 6mm cap plate connected by fillet weld. Where hollow members are to be galvanized, vent holes shall be provided in accordance with the specification.

H7. Pre camber values shown on the drawings refer to the fabricated shape before loads are applied.

10. CHASES AND HOLES

The number and position of chases and holes should be in accordance with the specification. Chases and holes for services should be cut neatly. Follow the recommendations below, but if they conflict with either the specification or with the size limits set by the masonry unit manufacturer then obtain the necessary instructions.

- J1) Do not cut chases in any block masonry that is less than 75mm thick.
- J2) Maintain a minimum of 15mm thickness between the bottom of the chase and the void for hollow units, unless otherwise recommended by the manufacturer.
- J3) Do not cut horizontal or raking chases in solid walls to a depth greater than one-sixth of the thickness of the leaf.
- J4) Do not cut vertical chases to a depth exceeding one-third the thickness of the single leaf in solid walls.
- J5) Offset chases on either side of a wall by a distance at least equal to the wall thickness. ensure that chases back-to-back in line do not exceed the dimensional restrictions in H1. and H2.
- J6) Do not cut holes exceeding 300mm wide in walls unless a suitable lintel has been specified. Commentary, Mechanical Rotary Cutters should be used, particularly when it is necessary to avoid heavy impacts and vibration. Inappropriate chasing carried out not in accordance with the specification might impacts and vibration. Inappropriate chasing carried out not in accordance with the specification might adversely affect one or more of the functional requirements of the wall, e.g. its load bearing capacity.

Permissible Deviations (mm)

Position in plan of any point or face in relation to the specified building

Reference Line and/or Point at the Same Level ± 10

Straightness in any 5 m Length ± 5

Verticality up to 3 m Height ± 10

Verticality up to 7 m Height ± 14

Overall Thickness of Walls ± 10

Level of Bed Joints up to 5 m for Brick Masonry ± 11

Level of Bed Joints up to 5 m for Block Masonry ± 13 .

11. RECTIFICATION OF DEFECTS

SCOPE

This section specifies methods for rectification of defects such as cracks in masonry walls or concrete, honeycombs, etc. in structural or non-structural elements.

DESCRIPTION OF WORK

The Contractor is entirely responsible for repairing all defects that may occur due to improper practice of work adopted in the site or due to natural phenomenon, liner differential shrinkage, solar radiation effect etc,. The contractor shall handover a defect free building to the client.

Any defect shall be noticed to the Engineer prior to implementing repair work and rectification methods shall obtain prior approval of the Engineer. The extent of repair work shall be to the satisfactory limit of the Engineer. Final selection of material types, equipment, etc. to be used for rectification works shall be in accordance with this Specification.

Tests may be carried out for checking the adequacy of the repair work after rectification of any defect in structural members according to Engineers interest. Unsatisfactory work may need re-rectification or re-construction. Any cost in repairing, reconstructing or testing shall be borne by the Contractor.

EXTENT OF WORK

Repair work shall carry out at following locations but shall not limit to following.

- Cracks in reinforced concrete members due to segregation, crazing, excessive drying, etc. as a result of insufficient or delay in curing.
- Cracks in non structural members such as masonry walls due unforeseen effects.
- Cracks in concrete members due to early removal of formwork.
- Honeycombs in concrete due to poor compaction.
- Exposed reinforcement due to improper provision of cover blocks or any cover provision method.
- Improper concreting due to bad arrangement of dense reinforcement.

The Contractor shall take all necessary precautions to avoid above and/or any other defects in site by good quality control of work.

RECTIFICATION METHODS

SYSTEM DESCRIPTION

Performance

The selected material as appropriate for defect rectification shall be a product, produced and tested for the purpose and shall not disturb the structural integrity or non structural appearance at any location where applied. Design and apply the repairing system(s) so that the strength, durability, etc. are not changed and the appearance of the original structure is not despoiled.

Tests

Select materials which have been tested and certified as applicable to each rectification requirement and as listed by qualified testing agency.

Defect Rectifying Sealants

Provide systems tested in accordance with relevant standards for type of defect required. Provide a seal according to manufacture's recommendations depending on the defect to be repaired. The defect rectifying system shall be based on an adhesive material so that proper bond between defective concrete and sealing material is ensured.

Surface Preparation

Make appropriate extent of area of surface to be treated structurally sound and free from contaminants such as oil, grease, curing membranes, previous coatings, dust, etc. Vacuum clean or use water to clean the surface as required by the manufacture's application guide.

Primers

Provide systems tested in accordance with relevant standards certifying a proper bond between new and old surfaces. Priming may not recommended if the mortar is to be applied by spraying.

Mixing

Mix required proportions of ingredients properly to the recommended limit. Use mechanical mixing if required by the manufacturer. Do not add any extra ingredients to the mixture than specified by the manufacturer.

Placing

Use correct tools and accessories recommended by the manufacturer to place the sealing or filling material. Apply in required number of layers.

Curing

Provide adequate curing to the repaired area for achieving optimum performance. Use a suitable curing compound as per manufacturer's instructions.

Compatibility

Provide rectifying systems only that are explicitly recommended by the manufacturer for the application, and which have been determined by tests to be totally compatible with the adjoining construction and each other, as stated in the manufacturers published data certified by the manufacturer for each application. After completion of curing the corrected area shall be capable of carrying all design dead and live loads of the original structure.

Material Content

Provide rectifying materials which are non-toxic, non hazardous, and do not contain asbestos fibres or dust particles or other substance prohibited by law.

Accessories

Provide components for each defect rectifying system that are needed to install repairing materials. Use only components specified by the manufacturer for the designated rectifying systems.

SUBMITTALS

Design Drawing

Furnish design drawings for the installation of the work including all important details. This shall include the size of treatment area, arrangement of accessories (if applicable), size and shape of defect, size and thickness of sealants and the surrounding construction to a sufficient extent. Indicate the function of defective area.

Supplementary Product Literature

Submit for Engineers' information. Furnish manufacturers literature describing the general properties of each product to be used in the work.

Certification

Submit the following.

Manufacturers Certification: Furnish certification signed by the primary manufacturer of the defect rectification materials, stipulating which systems are proposed for use in the particular work.

System Test Reports: Furnish certified test reports from the testing agency, indicating identification of the corresponding system design number, a test summary and a conclusion verifying compliance with specified requirements.

Statement of Manufacturer's Review

Submit statement signed by the subcontractor, stating that the defect has been reviewed with qualified representatives of the materials manufacturer and that they are in agreement that the selected materials and systems are proper and adequate for the application shown including compatibility with adjacent systems and materials.

QUALITY ASSUARANCE

Subcontractors Quality Assurance Responsibilities

Subcontractor is solely responsible for quality control of the work and undivided responsibility of the defect rectification systems for the entire work.

Qualified Installer

Rectification work shall be performed by a firm having a minimum of 3 years experience in the relevant field and on projects comparable to this project. The installer shall be trained and approved by the manufacturer in the use of the materials and equipment to be employed in the work, if skilled persons are to handle work.

Manufacturer

Provide materials for each type of rectification produced by one manufacturer for the entire project. Do not use materials produced by any manufacturer who will not agree to send a qualified technical representative to the project site, when requested, for the purpose of rendering advice concerning the proper installation of materials. Furnish the service of a technical representative as the work progress.

Field Samples

Provide a field sample for each type, condition and application of rectification in the building at final locations. Utilise the same materials and installation methods in the sample as required for the final work. When accepted, sample areas shall serve as the standard for materials, workmanship, and appearance for such work throughout the project and shall remain a part of the final work.

EXECUTION

REPAIRING CRACKS IN CONCRETE

Rectification of larger cracks

Following procedure shall be adopted in rectifying all cracks that would appear in concrete as a result of shrinkage, excessive drying, early removal of formwork, etc.

Rectifying Procedure

- Clean the concrete surface along the crack on the slab and soffit to remove dust, or any other contaminants and vacuum clean the area. If the crack is contaminated with oil or grease remove that area before vacuum cleaning.
- Install injection ports along the crack line on the top side of the slab at intervals not exceeding 150mm (depending on the severity and extent of the crack) using a suitable epoxy resin based bonding paste, which are using in general constructions
- If the concrete surface at the crack is not flat or not sufficiently clean to have a strong enough bond between concrete and ports use injection nipples with drilled holes of 50mm deep and having a 5mm diameter.
- If the crack has propagated through the entire section and if the section thickness is greater than 500mm drill holes on both sides of the member.
- Seal the surface of crack between injection ports with the same epoxy.
- Seal the surface of crack at soffit with the same epoxy.
- Allow the epoxy a sufficient time to cure.
- Inject a suitable solvent free epoxy resin based grouting mixture of low viscosity from one end until there is an appearance of the epoxy at the next entry port above the lowest port.
- Discontinue injection and transfer to the port above the port where the epoxy had appeared.
- Continue injection at every other port returning on completion to the first entry port that had not been injected.
- When the crack has been completely filled, allow sufficient time for epoxy adhesive to cure.
- Remove the entry ports and surface seal materials.

After rectification of cracks load tests shall be carried out at selected locations as deemed by the Engineer, if necessary.

Performance of the sealant can be checked by any leakage of water through the rectified crack after ponding.

Rectification of widespread finer cracks

An alternative procedure shall be adopted in repairing cracks which are short but has been spread in larger areas on concrete surfaces.

Rectifying Procedure

- Clean the concrete surface to be treated to remove any contaminant materials to ensure proper adhesion.

Static Cracks

- For static isolated cracks or cracks of less than 1.5mm, apply a primer followed by a base coat to fill and overlap the crack 75mm either side.

Dynamic Cracks

- Dynamic isolated cracks and cracks over 1.5mm shall be routed to a minimum of 5.0mm x 5.0mm and shall be filled with approved sealant. Install bond breaker tapes to prevent adhesion to the sealants at the bottom and then apply the primer.
- Allow the primer to dry tack free.
- Fill the prepared area with a suitable base coat.

The method of sealing a crack is shown in Fig 3.1.

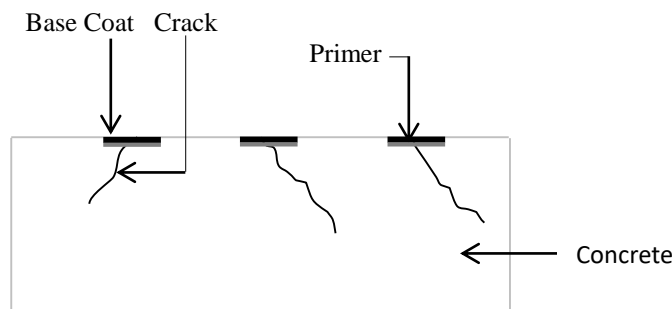


Fig 3.1: Sealing of cracks in concrete

REPAIRING HONEYCOMBS

Small and Moderate Sizes

Honeycombs of small to moderate sizes in concrete members shall be repaired by following method.

- Hack and remove the weak concrete area to expose the sound surface.
- Saw cut the boundary of repair area perpendicular to the surface to at least 10mm depth and remove concrete in the saw cut boundary to at least that depth.
- Wash and clean the hacked area using a water jet to make free from dust and loose particles.
- Hack around steel bars to have at least a 25mm clearance for grout to grip the steel bar.
- Grit blasting shall be used in removing corrosion products in reinforcement.
- Replace the affected part of the reinforcement bars if the diameter is reduced more than 20% of the original. Prior approval of the Engineer shall be obtained to remove or replace any reinforcement from any member.
- For protection of reinforcement from corrosion coat the bars with a zinc rich epoxy primer.
- Prepare the final surface free from dust and debris and to a rough profile with at least 5mm level difference surface troughs and ridges.
- Saturate the prepared surface with water for at least 1 or 2 hours.

- Prepare a primer (a bonding slurry by mixing a suitable polymer emulsion based on styrene butadiene with cement in recommended proportions by the manufacturer).
- Wet cementitious surface with water and apply the slurry. Application of primers shall be avoided if the mortar is to be applied by spraying.
- Build up the area with a non-segregating, shrinkage compensated, thixotropic mortar with high strength while the slurry is in wet condition. Manual placing of first layer may give better results.
- Cure the repaired area with water for a minimum of 3 days.

Fig 3.2 shows a typical detail of a repaired honeycomb.

The same procedure shall be adopted in repairing honeycombs deeper than 25mm, but shall be filled up in multi layers to prevent from material sagging.

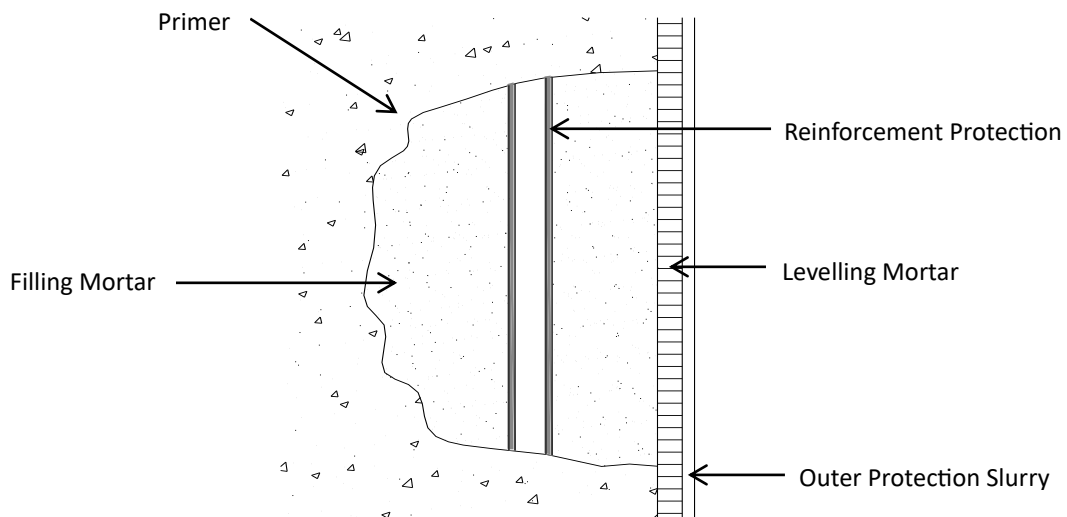
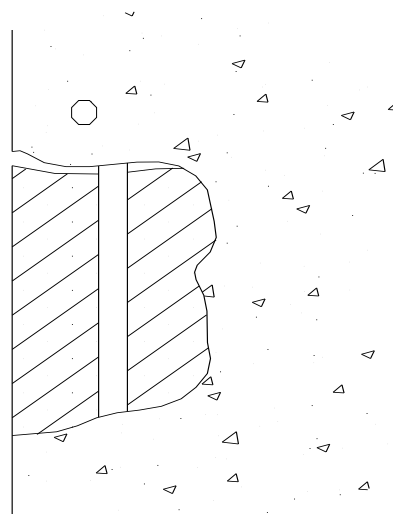


Fig 3.2 Typical Detail of a Repaired Honeycomb

Any defect during and after rectification of honeycombs shall be avoided or minimised by good quality control of work.

Figures 3.3 and 3.4 show possible defects that can take place during and after building up the honeycomb.

Fig 3.3 Defects After Building Up the



Honeycomb

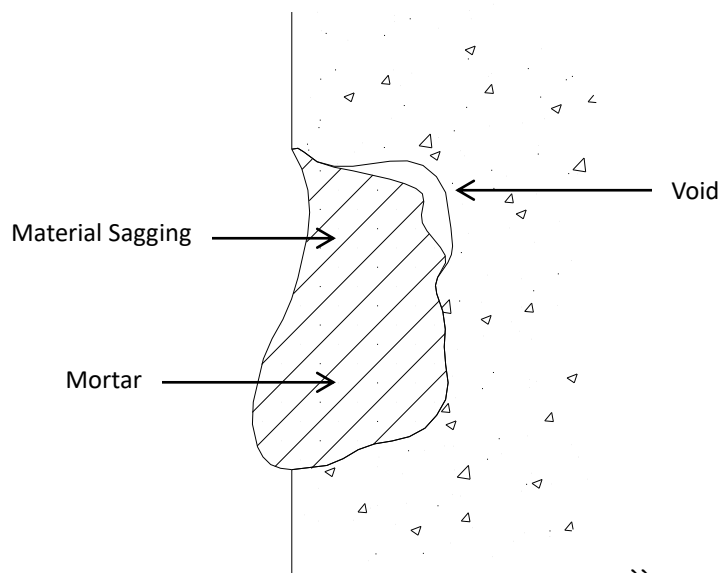


Fig 3.4 Defects during Building up the Honeycomb

Large Areas

Following procedure shall adopt in rectifying larger honeycombs.

- Hack and remove the weak concrete to expose sound surface.
- Remove weak concrete around reinforcement to give a 12mm to 15mm clearance for grout to grip the steel bar.
- Use a water jet to wash and clean the hacked area to free from dust and loose particles.
- Fabricate and install formwork with adequate inlet, level checking, sealing opening and a drain out plug.

- Formwork and openings shall be adequately sealed.
- Prepare a platform on top side creating a head for easier grout flow (if required).
- Saturate the area using clean water for a minimum of 2 hours.
- Mix a non shrinking high strength grout with a cementations grout and 12mm aggregates according to manufacturer's Specifications.
- Pour the mixture as shown in Fig 3.5.
- Cure the application for a minimum of 3 days.

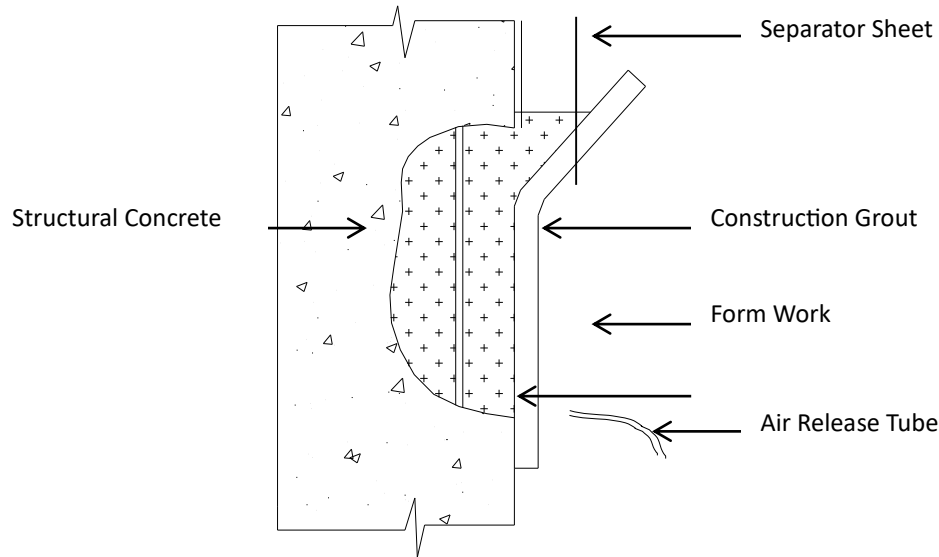


Fig 3.5 Rectification of Larger Honeycombs

REPAIRING LARGE CRACKS IN MASONRY WALLS

Following procedure shall be adopted in rectifying cracks in masonry walls.

- Set up scaffolding up to required height.
- Expose the crack and clean to free from contaminants.
- Install injection ports along the crack with a polymer modified lightweight cementitious repair mortar
- Seal the crack between injection ports with the same material.
- Allow to cure for a sufficient time (about 2 days).
- Inject water through injection ports and saturate the voids thoroughly.
- Mix a polymer emulsion based on styrene butadiene (bonding agent) with cement and a chloride free additive which can provide high fluidity to ordinary sand-cement grout mixes at a low water cement ratio.
- Inject the above mixed slurry from the lowest end until it is appeared from the next entry port above the lowest port.
- Discontinue injection and transfer to the port above the port where the slurry has appeared.
- Continue to inject every other port returning on completion to the first entry port that has not been injected.
- When the crack has been completely filled allow sufficient time to cure.
- Remove injection ports and seal it with the same emulsion.

REPAIRING PLASTER CRACKS IN MASONRY WALLS

Repair Method

Crack Width below 0.2mm

Apply only Elastometric Formlast (Acrylic Polymer) of the seal flex paint and apply the wall paint match to colour.

Crack over 0.2mm

- Cut a recess with 5mm grinding disk along the crack line up to brick level.
- While the recess remains dust free, fill with a mixture of Smart Seal PU 1 and filler mixed with appropriate proportions and finish to the surface level.
- Leave for curing at least for two days.
- Paint with a flexible paint based on acrylic polymer.

CLEANING

During installation, provide masking and drop cloths to prevent repairing materials from contaminating any adjacent surfaces.

Remove equipment, materials and debris, leaving area in undamaged, clean condition.

RECOMMENDED MATERIALS

Following materials that are producing by Master Builders Technology can be approved as suitable for repairing wok.

Table 3.1: Recommended Materials for Rectification Work

Material	Application
Concressive 1438	Sealing cracks in concrete and masonry
MBT Injection Resin Twin Line	Grouting fine cracks, voids, honeycombs
Primer 770	Primer for concrete
Sonoguard	Base coat for sealing cracks in concrete
Barra Mortar L	As a no sagging easily workable mortar for sealing cracks in masonry walls
Barra Emulsion 57D	As a bonding agent which bonds freshly placed concrete, mortar, etc. to concrete or masonry surfaces
Rheomac GF300	Additive which gives high fluidity to ordinary sand cement grout mixes at low water cement ratio
Emaco S188	As a non segregating, shrinkage compensated, thixotropic repair mortar with high strength for filling honeycombs and voids
Construction grout	As a grout of high strength for filling larger honeycombs
Masterflow 98	Mixing agent for construction grout to give extended working time
Smart Seal PU 1	Sealant to seal cracks greater than 0.2mm
Elastometric Formalast	Acrylic polymer to apply on cracks before painting

MEP SPECIAL SPECIFICATIONS

1. Technical Specifications for Plumbing Services
2. Technical Specifications for MVAC System
3. Technical Specifications for Fire Services
4. Technical Specifications for Electrical Services
5. Technical Specifications for Extra Low voltage System
6. Technical Specifications for Diesel generator
7. Technical Specifications for Solar System
8. Technical Specifications for Vertical Transportation system

1. TECHNICAL SPECIFICATIONS OF PLUMBING SERVICES

1. General

The work covered in this section shall include, but not to be limited to all labor, materials, equipment and services required in connection with Plumbing services, Plumbing services and related work as stipulated in the specifications, drawings and the equipment list for the proposed Central cold chain facility at Hulhumale. This specification shall be read in conjunction with all other parts of the Bidding documents and the accompanying drawings.

1.1 Preliminaries

The scope of work under this specification covers manufacture/ procurement, assembly, shop inspection & testing, shop painting, transportation of materials to site, storing, unloading and transportation from store to site and handling at site, erection, testing, commissioning and performance guarantee tests of equipment and accessories of all plumbing services of the project.

The scope of work by the Contractor shall include but shall not be limited to the following:

To select, manufacture and supply complete all mechanical services and associated equipment specified under this technical specification.

Though its mention or nor all brackets/supports (internal & external) should be hot dipped galvanized to the minimum of 65µm complying to the Class 4 requirements.

Supply of commissioning spares as may be required during erection, start up and initial operation of all the units/ systems till successful completion of commissioning. The price for commissioning spares should be deemed to be included in the contract price for the systems offered. Supply of recommended spares for two years' normal operation of the total plumbing services with item-wise price breakup. The price for the two years' spares shall be deemed to be included in the contract price for the systems offered.

Supply of special tools & tackles required for maintenance of all plumbing services. Preparation and submission of a necessary load calculations, general arrangement drawings, design drawings, fabrication & erection drawings, as built drawings, drawings of fast wearing parts etc. Approval shall be taken on the load calculation, system layout drawings and equipment general arrangement drawings before start of erection of all the equipment and complete of total plumbing services system as per approved drawings and instructions of site engineer of customer / Owner/ Consultant.

Minor civil work like breaking of wall /floor /roof to make duct / pipe / cable passage and adjustment to civil foundations as required for erection and finishing and making good of the same after erection work including painting thereof. Fixing of anchor fastener on wall and ceiling for support is included.

Any other item /nature of work which is specifically not appearing in the technical specification but directly associated with the efficient working / completion of the system covered in the specifications.

Performance testing of various equipment associated with all plumbing services at manufacturer's works and also performance testing all plumbing systems at site.

All necessary skilled/unskilled personnel, cranes, hoist, tools and tackles, instruments and accessories shall be arranged free of cost by the Contractor for assembly, erection, performance testing and commissioning of the systems.

Tenderer must note that completeness of systems for safe, smooth, trouble free operation and compliance with Local/International regulation is the sole responsibility of the Contractor i.e., the successful Tenderer. With this objective in mind, the Tenderer should include all the items essential for the efficient operation of the systems and other items which are required to complete the erection and foolproof commissioning of systems in respects. Whether the items are mentioned in the specification or not, all such items are treated/considered to be included in the specifications.

When any services passing the fire rated compartments/Wall or any barriers all sleeves or opening to be properly sealed with fire rated sealants. An approved type of fire-stopping system shall be used to seal all openings through walls and floors against the spread of fire and hot gases after the installation of cables, pipes and ducts as well as abandoned openings.

The fire stopping system should be easily applied, intumescent and resistant to water, solvents, acids, humidity and other industrial influences. The applied thickness shall give a fire rating equivalent to that afforded by the partition or floor in which the opening is made. Where necessary, a specialist shall be employed and paid, by the contractor, to carry out the fire stopping work.

Contractor i.e., the successful Tenderer shall be solely responsible to provide the above items at site without any extra cost implication to Client.

1.2 General Instructions to Tenderer

The technical specification inclusive of instructions/special instructions to Tenderer shall be read along-with General Conditions of Contract (GCC) and instructions to Tenderer, for the supply and erection of plant, machinery, and equipment.

All items of equipment in this specification shall be complete in all respects including mechanical and electrical equipment as specified including fasteners, bolts and nuts, gaskets, base frames, stiffeners, supports etc. and any item not covered in this specification but essential for superior design, operation and guaranteed performance of the system shall be included by the Tenderer.

The equipment shall be designed, manufactured and tested in accordance with the relevant international and local standards prescribed wherever possible.

The equipment offered shall be suitable for continuous, smooth, efficient and trouble-free services in the climate prevailing at the site, continuous duty conditions.

At the time of inspection, the Contractor shall furnish internal routine inspection certificate, material certificates, approved drawings, etc. to the inspector. Inspection shall be regarded as check-only and shall in no way relieve the Contractor of his responsibilities to provide systems & equipment functions as designed.

The Contractor Shall take full responsibilities for the guaranteed operation and achieving rated out-put and performance of the systems offered as per relevant clause of specifications.

The Tenderer shall provide information required for the smooth functioning of the systems including operation, day-to-day maintenance, preventive maintenance, capital repairs, schedules and programs and any other information required by the Purchaser for trouble-free operation of the systems along with the supplies.

The scope of work for the Tenderer should not include provision of room and foundation for the systems. However, the necessary load data shall be furnished along with the offer by the Tenderer so as to complete the civil work at site as per the schedule of completion of respective buildings.

The Contractor shall ensure that all rotating elements viz impellers of fans and crank-shaft, piston assemblies shall be statically and dynamically balanced as per the relevant International / ISO standards.

The Contractor shall ensure that the speed of operation of all the mechanical and electrical equipment including technological auxiliaries and service equipment shall be kept low enough to reduce noise, vibrations and wear. When design parameters require higher speeds of operation of certain equipment, more than one stage shall be chosen over preference to choosing higher speeds.

The Contractor shall adhere to the schedule for supply, erection, testing and commissioning etc.

The Contractor shall ensure that each equipment is provided with name plate engraved in English language with the details like Supplier's address, operation and design parameters, weight, and precautions etc.

The Contractor shall ensure that the systems are designed considering the fire safety norms and adequate fire safety measures in the form of hardware interlock provided accordingly.

This section applies to all sections of plumbing services except as specified otherwise in the individual sections.

The work to be done under this section of the Specifications consists of the fabrication, complete in all details, at the subject premises, and all work and materials incidental to the proper completion of the installation, except those portions of the work, which are expressly stated to be done by others. All works shall be in accordance with the governing Codes and Regulations and with the Specifications, except where it conflicts with such Codes, etc., the former shall then govern. The requirements in regard to materials and appliances, necessary for the complete installation of the work specified herein and indicated in the drawings. These specifications are intended to provide a broad outline of the required equipment but are not intended to include all details of design and construction.

Complete plumbing services shall be furnished and installed as shown on drawings and specified under this section. Coordinate timing of installation with work of other trades.

Systems provided shall be complete and operable, and shall include required accessories, fastening, and supports. One coat of primer shall be provided for all fastenings and supports.

1.3 Standard Codes and Regulations

All works performed, and equipment and materials supplied and installed under the contract shall comply in every respect with the rules and regulations of,

- ✓ Relevant local regulations and codes
- ✓ Current Edition of the Relevant British Standard Codes of Practice. The relevant British Standard Specifications (BS) or approved equivalent
- ✓ All other authorities have jurisdiction over the installation

1.3.1 Standards Compliance

Materials and equipment specified to conform to referenced standards and codes require proof of such conformance. Labels or listings indicating such compliance are acceptance evidence. In lieu of label or listings provide a certificate from an independent testing organization acceptance to the Engineer.

For materials and equipment whose compliance with organization standards or specifications is not regulated by listing or label, provide manufacturer's certificate of compliance.

Certificates of compliance shall identify manufacturer, product, referenced standards and manufacturer's certification that the product conforms to all requirements of the project specification and listed reference standards.

1.4 Authorities Inspection, Testing and Approval

The Contractor shall file all plans, application permits, etc., and shall complete all tests, forms, etc., arrange all inspection etc. as required by all rules and regulations, etc., of all the government authorities having jurisdiction and such shall be completed by personnel of proper caliber, in particular, professional engineers, where so required.

The work shall not be covered prior to the inspection and the approval of the authorities. The Contractor shall give due notice as required by the authorities whenever such works are ready or about to be ready for inspection and testing. They shall afford full opportunity and co-operation of the authorities to carry out the inspection and testing and shall deemed to have allowed in the tender sum for such inspection, any fees payable, any necessary phasing and temporary suspension of works and other cost resulting thereby.

Should any work be covered without prior inspection and approval, the Contractor shall uncover any parts or part of the work or make openings in or through the same, as the authorities may direct for inspection. The Contractor shall at its own expense reinstate and make good any such part or parts to the satisfaction of the authorities and Superintending Officer.

The Contractor shall furnish all required Certificates of approval.

1.5 Schedule of Technical Data and Manufacturer's Technical Pamphlets

Manufacturer's Technical Pamphlets giving full technical data for all equipment to be offered by the Tenderer shall be submitted together with the Tender. The schedule of technical data shall be duly filled. Equipment to be offered by the Tenderer shall bear both Manufacturer's Name and List Number.

Phrases like "As Specified", or "Equivalent", "Submit at a later date", will not be acceptable in the schedule of technical data.

Where there is a discrepancy between the schedule of technical data attached to the Tender documents and the specifications mentioned on manufacturer's technical pamphlets, the schedule of technical data should prevail.

Tenderers must fill in their tender strictly in compliance with the Engineer's base specification in regard to nominated makers of equipment/material. Any error in specifications must be clarified with the Engineer before submission of tenders, who will issue addenda thereof.

The original form of schedule of technical data must be filled in accordance with the Engineer's base specification or amendments thereof, failing which the client reserves the right to ask the Tenderer to comply with Engineer's base specification at tendered price or else the client reserves the right to forfeit the Tenderer's Tender Deposit and Tender Bond.

Tenderers are fully encouraged, however, to propose alternative specifications which can achieve genuine economy in cost or technical benefits, but these same alternatives and their cost implication thereof must be filled separately in a separate covering letter with a Schedule of Technical Data and not the original Tender Schedule.

1.6 Equipment and Material Approvals and Samples Review

Within 14 days after the award of any contract, the Contractor shall submit for approval a list of manufacturers of equipment and material proposed for the work. The Contractor's intent to use the exact makes stated in their tender does not relieve them of the responsibility of submitting such a list. All equipment and materials should be new and unused.

Wherever the words "equal", "approved equal", "as approved" appear in the specification, this shall mean approved in writing by the Consulting Engineer.

Each item of equipment shall be a standard catalogue product of an established, reputable, approved manufacturer. All similar equipment shall be of the same manufacturer, type, class and finish, unless otherwise specified.

Where manufacturer's catalogue numbers or types are specified or shown on the drawings, they are generally intended to be used as a guide and are not intended to take precedence over the basic duty and performance specified or shown. In all cases, verify the duty with the particular characteristics of the equipment offered for approval.

Where no alternative materials are noted in the specification or on the drawings and where the words "equal", "approved equal", or "as approved" etc., do not appear, the exact make specified must be supplied and installed. Equipment orders shall be forwarded to the Consulting Engineer for approval before purchase.

1.6.1 Samples

Where approval of products is specified submit samples or other evidence of suitability for review by the Engineer. Resubmit samples as necessary until an acceptable standard is reached. Do not confirm orders, commence manufacture or use products until approval of samples has been obtained.

1.6.2 Materials Application

Materials submitted for review shall be forwarded using a standard application format to be agreed with the Engineer. Enter the date by which review information is required. Allow a reasonable time for review and indicate urgency where necessary.

Where manufacturers are nominated in the specification or in the following schedule they are intended to define acceptable standards of equipment.

All necessary skilled/unskilled personnel, cranes, hoist, tools and tackles, instruments and accessories shall be arranged free of cost by the Contractor for assembly, erection, performance testing and commissioning of the systems.

Tenderer must note that the completeness of system for safe, smooth, trouble free operation and compliance with Local/International regulation is the sole responsibility of the Contractor i.e., the successful Tenderer. With this objective in mind, the Tenderer should include all the items essential for the efficient operation of the systems and other items which are required to complete the erection and foolproof commissioning of systems in respects. Whether the items are

mentioned in the specification or not, all such items are treated/ considered to be included in the specifications.

Contractor i.e., the successful Tenderer shall be solely responsible to provide the above items at site without any extra cost implication to Client.

When any services passing the fire rated compartments/wall or any barriers all sleeves or opening to be properly sealed with fire rated sealants.

1.6.3 Review Categories

Shop drawings, Materials Samples and similar submittals will be reviewed and classified in one of the following categories:

A	approved without comment	- no resubmission required
B	approved when comments are fully complied with	- no resubmission required
C	approved with comment/s	- to be re-submitted
D	disapproved	- to be re-submitted

1.6.4 Equipment and Material Deviations

The dimensions and ratings of equipment specified herein or indicated on the drawings are intended to establish the outlines and characteristics of equipment furnished by the particular manufacturer or manufacturers specified.

Where the Contractor intends to use an item of equipment or material other than that specified or shown in the drawings or in the schedules, the Consulting Engineer's approval therefore must be obtained in writing.

Should any tenderer include in his offer equipment or material other than that shown in the drawings and schedules, such equipment or material must conform fully to the requirements for these items as shown in the drawings and schedules. Acceptance of any tender which includes equipment and material which differ in any respect to that equipment and material shown on the drawings and schedules, in no way relieves the Contractor from complying with the specification, drawing and schedules.

Where such approved equipment deviations require a different quantity and arrangement of piping, wiring conduit and equipment from that specified or shown on the drawings, the Contractor shall furnish and install any such additional piping, structural supports, electrical materials, insulation, controllers, motors, starters and equipment required by the system without additional charge.

1.7 Submittal

The following items shall be required to be submitted to the Engineer for review and certification.

a. System Design Calculation

Assumptions and basis of selection for the system components. Design calculations as required by the Engineer for review.

b. Design and Shop Drawings

Complete system design layout and description of components for all piping schedules. schedule and description of pipe fittings and valves.

c. Test certificates for the system.

1.8 Intent of Drawings and Specifications

It is the intent of the specification and drawings relevant to this Contract to call for finished work, tested and commissioned. Any apparatus, appliance or material not shown on the drawings, but which is mentioned in the specification or vice versa, or any incidental appliance or materials, services which may be necessary to make the work complete and perfect in all respect and ready for operation, even if not particularly specified, shall be furnished, delivered and installed without any additional costs.

The plan as drawn are based upon architectural plan and detail and show conditions as accurately as it is possible to indicate them in scale. The plans are diagrammatical and do not necessarily show all accessories, fixings etc., necessary to fit the building conditions.

The locations of outlets, apparatus and equipment shown on the plans are approximate. The Contractor shall be responsible for the proper location of all devices to make them fit with architectural details and instructions from Engineer's representative at the site.

1.9 Shop Drawings, Working Drawings and Details

After receiving approval of the equipment manufacturers submit for approval, without delay, and prior to purchase or fabrication, not less than three copies of detailed, dimensioned shop drawings or cuts of equipment showing general construction, size, arrangement, levels and setting out details, fixing details, operating clearances, related builders work information and requirements, performance characteristics and capacity of all specialties, together with sufficient engineering data to indicate substantial compliance with the respective specifications. Positions of all control equipment, including related components, shall be shown on shop drawings. Each item shall be identified by name and numbers as shown on the equipment schedules, control drawings and specifications.

Working drawings of the complete installation, prepared by the Contractor shall be submitted in triplicate for examination and comment. Each drawing will be examined and approved or corrected or disapproved by the M&E Engineers, and returned to the Contractor, who shall then print the necessary copies of each approved submission for distribution. Disapproved drawings shall be corrected and resubmitted.

Drawings shall be of 1:100 minimum scale, except in critical areas where 1:50 or larger scale as appropriate shall be used.

Inspection of shop and working drawings shall not be considered as a guarantee of measurements of building conditions. Where drawings are inspected, such inspection does not in any way relieve the Contractor from his responsibility nor from the necessity of furnishing material or performing work required by the contract drawings and specification, which shall, in the event of a dispute, take precedence over shop drawings.

The submission of shop and working drawings (in either the original submissions or resubmitted with corrections) constitutes evidence that the Contractor concerned has checked all information thereon and that they accept and are willing to perform the work as shown in a workman like manner and in accordance with the best standard practice. It also constitutes evidence that all control diagrams, all electrical diagrams and all submissions of any kind are fully understood by the Contractor and that in their opinion the equipment will perform as specified. No claim for extra shall be based on work shown on shop and working drawings, unless such claim is so noted on the Contractor's transmittal letter accompanying the drawings.

A responsible person of the Contractor's staff shall sign all drawings submitted, including those by suppliers.

Submit for approval within fourteen (14) days of the contract being awarded two (2) copies of a schedule of shop drawings showing the following:

- ✓ Drawing Number
- ✓ Title
- ✓ Planned Date of Submission

Dates of submission and approval shall be coordinated with the Building Programme. Shop drawings shall be submitted for inspection to the M&E Engineer, at a minimum of 14 days prior to the required return date.

Failure of the Contractor to include all shop drawings on this schedule shall not relieve them of their responsibility to submit all required shop drawings on time to permit correct processing as specified herein.

The subcontractor is responsible for ensuring that shop drawings are kept up to date incorporating modifications arising from instructions. Re-issue updated shop drawings as may be required by the Engineer.

1.10 Record Drawings, As-Built Drawings, and Operation and Maintenance Manuals

- Record Drawings

During the course of the works the subcontractor shall maintain fully detailed records of all changes from the tender drawings to facilitate easy and accurate preparation of the record drawings and to ensure that these drawings are in all respects a true record of the installation.

- Content

The drawings shall show the complete installation, including the size and runs of all ducts and pipework. The scales shall be such that details, particularly of the plant, can be clearly shown. The drawings shall show the names of the manufacturer, model and type numbers and all the details of duty and rating of all items of the plant. The drawings shall include the geographical location and identification number of each circuit control valve in accordance with the labeling and circuit control diagram.

- **Diagrams**

A print of each of the composite record circuit and layout diagrams shall be fixed securely to the inside of the hinged front of the main electrical control panels as appropriate, or in such other alternative positions as may be agreed by the Engineer and shall be protected by nonflammable transparent material. Where inadequate space exists, the prints shall be suitably reduced in size.

- **Operations and Maintenance Manuals**

The Contractor shall also provide Operations and Maintenance Manuals, wiring diagrams, valve charts, test certificates and the like as required by these specifications. Three copies of the Operations and Maintenance Manual shall be handed to the Engineer before practical completion. 2 copies of the O&M manual in CD format shall also be submitted. The files in the CD shall be in PDF or text format.

- **Manual Format**

The format of the manual shall be A4 size white paper for typed pages with neatly typewritten text, and manufacturer's printed data. Drawings shall be sized so that they may be folded to the size of the text pages. Each volume title of the manual shall be identified with the typed or printed title, Operations and Maintenance Manual, the title of the project and the identity of the general subject matter covered in the manual. Each manual volume shall contain a neatly typewritten table of contents arranged in a systematic order giving: Subcontractor, name of responsible principal, address and telephone number, a list of the name, address and telephone number of the subcontractor or installer. Only the manufacturers printed data, which is pertinent, is to be included. Each sheet of manufacturer's instructions shall be annotated to identify clearly the specific item or part installed and the instructions applicable to the installation. All inapplicable information shall be deleted.

- **Supplementary Data**

Data shall be supplemented with drawings as necessary to illustrate clearly component parts of equipment and systems, control diagrams, flow diagrams and test procedures covered in the manual. Written text shall be organized into a consistent format under separate headings for different procedures and in a manner to provide a logical sequence of instructions for each procedure.

- **Organization**

Organize the Operations and Maintenance Manual as follows:

Volume 1

- ✓ Part 1 : Introduction
- ✓ Part 2 : System Description
- ✓ Part 3 : Operating Procedures
- ✓ Part 4 : Fault Finding
- ✓ Part 5 : Preventive Maintenance
- ✓ Part 6 : Appendices:
 - ✓ List of Drawings
 - ✓ Equipment Data and Spare Parts
 - ✓ List of Manufacturers and Agents

Volume 2

- ✓ Publications (catalogues, selection tables, etc.)

- Contents

The content of the manual shall include those items contained in the above schedule and for each item it shall cover the following points:

- ✓ Description of plant, equipment, component parts and finishes
- ✓ Operating procedures, including step by step instructions for pre-start, starting up, normal operation and shutting down of the plant, equipment and components, safety features
- ✓ Maintenance procedures, including routine operations, guide to troubleshooting and fault finding, procedures for assembly, repair and reassembly, and procedures for alignment, adjusting, checking and cleaning
- ✓ Servicing, lubrication and cleaning schedule, including list of lubricants required and filter replacement
- ✓ Manufacturer's printed operating and maintenance instructions
- ✓ Circuit directories of panel boards, dial servicing and instrument checking
- ✓ As installed color, coded wiring diagrams.
- ✓ Details of each item of plant, including the name and address of the manufacturer and local agent, type and model, serial number, duty and rating.

- Operations and Maintenance Instructions

The Contractor shall demonstrate and explain the plant and the method of starting, running and stopping to the Consultant or the Employer's representatives. During the defects liability period the Contractor shall allow for providing trained operators to attend, operate and maintain the plant as directed by the Employer's staff. Demonstrate

the purpose, function and operation of the installations including all items and procedures listed in the Operations and Maintenance Manual. Over this period the operators shall also instruct the Employer's staff in the correct maintenance and operation of all plant and equipment. The Contractor shall also assist the Employer in formulating any maintenance contracts with suppliers of equipment and Contractors that the Client may require. The Contractor shall provide three sets of operations and maintenance instructions (hard copies) and two soft copies of the O & M manual in CD format. The files in the CD shall be in PDF or text format.

- Record Drawings (i.e. updated shop drawings)

Unless otherwise indicated, the Contractor shall provide the following drawings before the practical completion:

- ✓ 3 sets of installation working drawings.
- ✓ 3 sets of detailed plant room drawings.
- ✓ 3 sets of purpose made diagrams detailing separately all the composite electrical circuit and wiring layouts.
- ✓ 3 sets of builder's work drawings.
- ✓ 1 set of reproducible fitted drawings, process negatives and computer discs for use with AutoCAD upon completion of the work

- Completion

Adjust copies of all Shop Drawings to record final installation. Submit three complete finalized sets before practical completion. Supply copies of all associated supplementary manufacturers or other data necessary to form a full and complete record of work done.

- Additional Data

Provide details of any errors, variations, omissions or additional information which is not instructed, directed or indicated on the subcontract drawings, but which becomes apparent from construction. Information is to enable record drawings to form an accurate record of final construction.

- Manufacturers' Input

Retain copies of maintenance instructions and documents delivered with components and equipment or obtain from manufacturer as necessary and submit before Practical Completion.

- Spare Parts

On completion of the testing and commissioning of the mechanical services installation, spare parts required by the specification shall be supplied and submitted.

- Lists

At the time of handover provide a comprehensive list of all manufacturers, suppliers and local agents for all items used in the construction of the works. Include the following data:

- ✓ Product/service
- ✓ Specification/instruction reference
- ✓ Company name
- ✓ Address
- ✓ Telephone and emails
- ✓ Contact name, title and position.

Upon completion of the job, the Sub-Contractor shall furnish to the Owner their original tracings or reproducible transparencies of all electrical works, shop drawings and equipment layouts. They shall note on the as-built drawings furnished by them, the corresponding number of the applicable shop drawings. Where shop drawings are not available, the Contractor shall neatly indicate the changes on the as-built drawings.

- As-Built Drawings

On completion of the installation, the Contractor shall prepare a set of As-built drawings incorporating all changes made to the original design and drawings, which drawings shall represent an accurate description of the installed systems. These drawings shall be bound with covers into an album and handed over to the Engineer.

1.11 Quality Assurance

The Contractor shall operate and maintain a Quality Assurance programme to ensure that the Contract is completed in accordance with the approved programme and to the standard specified. Work procedures shall be documented and shall be available to satisfy the effectiveness of this programme in the following areas at contract execution.

- ✓ Design
- ✓ Procurement, manufacture and packaging
- ✓ Construction and erection

- ✓ Manufacturer's Instructions

Where installation procedures are specified to be in accordance with the manufacturer's instructions, provide published copies prior to installation. Installation of materials and equipment will not be allowed until the instructions are received. Failure to furnish manufacturer's instruction can be caused for rejection of the materials.

- Completion and protection:

- ✓ Protection

Protect building finishes, fixtures and fittings and prevent damage to existing property. Move, cover and protect as necessary to enable the work to be executed and replaced in original positions upon completion.

- ✓ Special Protection

Wherever work is of an especially vulnerable nature or is exposed to abnormal risks provide special protection to ensure that damage does not occur. Replace or repair any damaged components or finishes.

- ✓ Waste Material

Remove rubbish, waste, debris and surplus material regularly and keep the site orderly and clean. Remove all rubbish, dirt and residues from voids and cavities in the construction before closing in. Dispose of waste material at an approved location and obtain all necessary permits.

- ✓ Cleaning and touch up

Remove all temporary markings, coverings and protective wrappings unless otherwise instructed. Clean finished work thoroughly, remove all surplus material. Cleaning materials and methods shall be recommended by product manufacturers. Touch up minor faults in finishes or repaint badly marked areas back to suitable breaks or junctions.

- Lubrication

Adjust, ease and lubricate moving parts of new work as necessary to ensure easy and efficient operation.

- Defects

Defects are to be reported to the Engineer without delay. Obtain directions before proceeding with work which may cover up or otherwise hinder access to defective construction or be rendered abortive by the carrying out of remedial work.

1.12 Painting

All surfaces to be painted shall be thoroughly cleaned and decreased and painted as follows:

All Pipes brackets should be Hot Dipped Galvanized & all external Pipes brackets should have a minimum 65 µmm film thickness.

- Equipment

Manufacturer's equipment does not need to be painted other than touching up due to site damage, provided the paint system provided has been properly applied and results in one of the following:

- ✓ 35 microns for oven baked enamel surfaces.
- ✓ 45 microns for sprayed and warm air-dried finishes.
- ✓ 80 microns for brush applied enamels

- Galvanized Surfaces

Shall be cleaned with a suitable pre paint treatment, immediately followed by one coat of galvanized iron primer, followed by one coat of undercoat in contrasting color, and one final coat to the specified color. For external galvanized surfaces and pipes, the subcontractor shall provide a paint system with suitable technical support to demonstrate that the oxidation rate of zinc will not be accelerated by the proposed painting system. The total dry paint film build up shall be 80 microns. The final coat need not be applied to externally insulated sheet metal ductwork. Touching up to damaged areas shall be zinc rich powder-based paint to give equal protection to undamaged areas.

- Mild Steel Surface

Pre-treatment shall be as per above, followed by one coat of anti-rust primer, 1 coat of metallic lead primer (or equal) in a contrasting color and one finishing coat of super enamel for a total paint buildup of 80 microns.

- Stainless Steel, Copper

Need not be painted, except for the identification of its use.

- Concealed Work

Pipe-work and ductwork concealed in walls shall be thoroughly cleaned and primed; finishing coats need not be applied.

- Areas with no Ceiling

For areas with no ceiling, the finishing coat shall be to the Architect's selected color.

1.13 Practical Completion & Handing Over

- Preparation

During the weeks leading up to practical completion, the employer and the engineering Consultants will monitor commissioning tests with the Contractor and his subcontractors. A programme of such tests is to be agreed well in advance to ensure a systematic and progressive approach towards building handover. The Contractor shall pay particular attention to the production of Record Drawings and Maintenance Manuals. Their production will be progressively reviewed in order that they are finished by the Date of Completion.

- Preparatory Inspection

Two weeks prior to the anticipated date of Practical Completion a formal inspection of the works will be undertaken jointly by the Architect, engineering Consultants and the Contractor. The Employer will be invited to send representatives to this inspection. Lists of defective and incomplete work are to be prepared together with the engineering Consultants, together with a check list of outstanding documentation related to the documents required to be handed over by the Subcontractor at practical completion. The engineering consultants will consolidate these lists and forward to the Subcontractor for action. Action related to the lists will be monitored in the remaining period to practical completion.

- Handover

As soon as the consultant is of the opinion that practical completion has been achieved, he will arrange a formal handover inspection with the Employer. Any remaining defects or pending documentation will be listed for immediate action by the Subcontractor within seven days unless otherwise instructed by the consultant.

The final handing over documents to be submitted by the Contractor on completion of the installation shall comprise the following:

- a) Operation and maintenance manuals (3 copies)

b) Commissioning sheets (3 copies)

c) Test reports (3 copies)

d) As built drawings (3 hard copies and 1 soft copy in CD)

These documents, in required number of copies specified, should be supplied to the Employer/Consultant within 30 days on the issue of taking over certificate.

- Defects Liability Period

Defects will be reviewed at joint site inspections with Consultants and Contractor. The Consultant will coordinate input from all disciplines and prepare a defects list that will be updated and reissued following inspections throughout the Defects Liability Period. Permission for access to accommodation for making good defects is to be obtained strictly in accordance with Employer, Contractor and user requirements. Defects are to be made good promptly and expeditiously.

- Training

The Contractor shall allow in his contract price the service of a competent personnel to instruct the Owner's maintenance staff in the operation and maintenance of the installation and equipment during the initial operation of the system, subsequent to the issue of the certificate of practical completion or handing over of the works to the owner whichever is earlier.

- Maintenance and Guarantee

All equipment supplied and installed shall be in good working order and shall be guaranteed for a period of 12 months from the date of handing over the completed installation to the Owner. This guarantee shall include the equipment manufacturer's standard warranties and the Contractor's own guarantee on all other materials supplied and installed by them.

The contractor shall make good any defects to the components of the equipment that may arise from fair wear and tear during the guarantee period. Any component of the installation which fail to achieve the guaranteed performance to be replaced by the Contractor without delay and without any charge.

During the above-mentioned guarantee period the Contractor shall provide free regular monthly maintenance to all plumbing services and ensure that all systems are maintained in first class running order. The maintenance shall include systematic examination, cleaning, adjustments, testing and lubrication and shall cover replacement of parts due to

fair wear and tear. During this guarantee period the Contractor shall also provide emergency breakdown maintenance.

The Contractor shall maintain a detail record of all services, maintenance and repair work carried out. Such record shall be prepared in duplicate and should be in a form of Maintenance/ Repair sheet, with one copy to be retained by the Owner upon the execution of such services. Records of such service, maintenance or repair shall also be entered in the maintenance logbook provided at the site.

The bidder shall submit the terms and charges for service and maintenance contracts along with the bid.

1.14 Testing & Commissioning

Bidders shall submit with the bids, a complete proposal with a time schedule for testing and commissioning of the plumbing systems. The program shall include a trial operation of all main equipment with any necessary adjustments to ensure that the system is working correctly. The Contractor shall provide all instruments and equipment together with commissioning engineers and adequate assistance for carrying out the commissioning and testing activity which shall be done in accordance with the recommendations of relevant standards. If any portion of the work fails to pass the tests, the Contractor shall, at his own expense carry out such alterations or replacements as are required to the satisfaction of the Engineer. The Engineer shall be at liberty to call for further commissioning when such alterations have been completed to their satisfaction. The Contractor shall provide commissioning spares at his own expense. Spare parts earmarked for maintenance shall not be used during this period.

1.15 Minimum Compliance

All existing underground drainage utilities that are known in the area should be indicated. These include piping, valves, manholes and pits. This coordination is necessary to avoid problems in the field of the relative location of the pipes being connected to.

Sanitary drainage should be of the two-pipe system where waste and soil drainage are separated and properly vented. Sanitary drainage should be conveyed by gravity to the external sewer network. Drainage from basement floor below the invert level of the existing network should be collected in pump pits and then pumped up to the external sewer network.

All roof, decks, canopies, balconies, terraces, etc., should be drained by gravity and led to the storm water network or other means of disposal. All areas below the drainage network level should drain by gravity to collection pits and be pumped up to the external network.

No building should be designed with combined storm water and sanitary drainage systems. Each system must be completely independent.

Extend internal drains out of the building as often as necessary to maintain required headroom in the building, consistent with the availability of site or street sewers on a particular side of the building.

Provide the building with ample stacks to serve the building requirements; maintain minimum offsetting of stacks and avoid long branches.

Drainage piping should not be run in elevator machine rooms, telephone rooms containing telephone equipment, relays and terminal strips; electric rooms and closets containing exclusively equipment such as transformers, switchgear, motor control centers, panel boards computers and electronics equipment or similar items of equipment; and in emergency generator rooms, except for piping directly associated with the generator unit.

Coordinate with the HVAC design so that necessary floor drains, funnel drains, etc., are provided reasonably adjacent to all HVAC equipment requiring drains.

Provide car parking areas with floor drains to carry off the water dripping from the vehicles and to allow for cleaning of the floor.

All pipe cleanouts should be readily accessible. They shall be exposed in unfinished areas or of the floor or wall type in finished areas.

Inlet piping and/ or ventilated manhole cover (or grating) must be large enough to allow entrance into the pit of the peak capacity of the pumps.

Sewage pump pits must be properly sealed and vented.

Make sure that the electrical engineer provides waterproof type wiring for sump pumps.

Where the lift is 10m or more, provide sump pumps with spring-loaded check valves instead of the regular swing checks used elsewhere.

Keep roof drains and stacks through the roof 300-450mm away from all parapet walls, building off sets, roof openings, etc., to allow for proper flashing. All stacks through the roof should be at least 110mm in size.

Supply drains in areas subject to dirt and grit with a free-standing bucket in the drain body.

This portion of the work shall be carried out by a Company registered/qualified to carry out the plumbing and sanitary installation works.

The sub-contractor shall provide the service of a Professional Engineer/Chartered Engineer with valid practicing certificate/seal to attend to all site meetings, inspections, testing, charge-in & turn-on with relevant Plumbing & Drainage Authorities.

Submission Document shall include;

- ✓ Graphical symbols, legend and general notes
- ✓ Floor plans show sanitary drainage, rainwater drainage, water supply, hot water distribution, etc.
- ✓ Schematic and riser diagrams of all of the above
- ✓ Layout plans for water distribution network, irrigation system, sewage system, etc. showing details of connection
- ✓ Equipment performance schedules
- ✓ Layouts and details of mechanical plant rooms
- ✓ Control diagrams
- ✓ Miscellaneous installation details

Whenever Consultant request contractor should submit for;

- ✓ Ratings of equipment including pumps, Water tanks, Geyser and other systems
- ✓ Pipe sizes, such as hydraulic calculations
- ✓ Sumps and pump pits sizing
- ✓ Other calculations and analyses that assist in design verification and as requested by the Consultant
- ✓ All design drawings, calculations has to be submitted with the professional engineer/charted engineer signature.

2. Plumbing Services

Provide all risers with drain valves. Where possible, all drain valves discharge shall be piped to a nearby drain.

All materials and equipment provided shall be in accordance with the Local standards. Potable water supply system materials and equipment must conform to the requirements of the Water Regulations Advisory Scheme (WRAS) of drinking water quality standards.

All valves shall be accessible for equipment maintenance.

Provide mains with sectionalizing valves at strategic locations such that each floor, Bathroom can be isolated independent of main building. In buildings, where practical, loop mains and generously provide them with sectionalizing valves. Valve all connections for future extension.

In providing water connections to the equipment, the connection should be as large as the connection on the equipment or larger if required to deliver the flow rate required with reasonable pressure loss.

Provide all fixtures and equipment requiring water with water in adequate quantities and at required pressures.

The cold-water system must be installed to provide a 1.0 – 1.5 bar and a maximum pressure as per manufacturer pressure at any plumbing fixture. Water velocities in the piping system should not exceed 2 m/s for quiet operation and where quick closing valves are installed, shock absorbing devices must be added to prevent water hammer.

Provide pressure-reducing valves should be provided as shown in the design drawings to reduce the excessive pressures.

The water consumption must be monitored by main incoming.

Provide hose bibs in all machinery rooms, Car Parks, Landscape areas with floor drains whenever required.

All hose bibs should be provided with vacuum breakers.

The section outlines the minimum acceptable standards for equipment and materials which are to be provided. Any deviation there from or an alternative offer of materials must be approved by the consultant engineer prior to placement of orders.

Minor equipment and materials not specified herein shall be provided in accordance with the best trade practice.

All pipework materials shall be new, free from defects and conform to the standards specified below.

Manufacturers shall warrant pipe and fittings for 10 years to be free of defects in materials or workmanship.

Warranty shall cover labor and material costs of repairing and/or replacing defective materials and repairing any incidental damage caused by failure of the piping system due to defects in materials or workmanship.

2.1 Pipe Material

2.1.1 Potable Water (Cold Water)

All cold water supply pipes and fittings shall be uPVC PNT11 or PNT14 as directed in the drawings and BOQ.

All pipes and fittings should be compatible to 1.5 times the working pressure.

All uPVC pipe & fittings shall be manufactured as per ISO 1452 and ISO 4422 and shall be complied to international standards like BS 3505, BS 4346, ASTM D1785, ASTM D2241, DIN 8061, DIN 8062.

2.1.2 Hot Water

All hot water supply pipes and fittings shall be PPR PN20. All PPR pipe & fittings shall be certified by NSF International as complying with NSF 14, NSF 61, and ASTM F 2389 or CSA B137.11

2.1.3 Sewer & Wastewater

All sewer and wastewater drainage pipes and fittings shall be uPVC PNT7 or uPVC PNT11 as directed in the BOQ and drawings. All discharge pipes and fittings from wastewater collection pits shall be uPVC PNT11. Pipes shall conform to BS 4514, BS EN 1401 & BS EN 1329 installed complete with standard molded fittings.

2.1.4 Storm Water

All storm water drainage pipes and fittings shall be uPVC PNT7 or uPVC PNT11 as directed in the BOQ and drawings.

2.1.5 Irrigation Water

All irrigation water supply pipes and fittings shall be uPVC PNT11. All drip irrigation pipes shall be Low Density Polyethylene (LDPE).

2.1.6 Vent Pipes

All vent pipes and fittings shall be uPVC PNT7 or as directed in the BOQ and drawings.

Any other pipe material shall not be used unless specified in drawings OR specifically approved in- writing by the M&E Engineer.

2.2 Pipe Work

2.2.1 General

All pipework, fittings and supports necessary for the proper functioning of the work, whether or not specifically shown on the drawings and/or called for in the Specification, shall be supplied and installed in full co-ordination with other services. The intent of this Clause is that, whereas all minor and incidental works are not necessarily shown and/or specified but are necessary for the completeness of the work, such items shall be provided within the Tender Price. Allowances shall be made in the Tender Price for all offsets and adjustments to pipe runs, etc. needed to overcome the obstructions of the building and other services despite the fact that they may not be shown in detail on the drawings.

All pipe sizes shown in the drawings are the nominal diameters (outside) diameters of the pipe.

When they run in protected areas such as fire lift lobbies, they shall be enclosed in fire rated construction, sleeves shall be properly sealed with fire sealants.

All pipework exposed to direct sunlight shall be protected with UV resistant paint.

All bends, junctions, etc. of sewer and drainage pipes shall have cleaning eyes and inspection openings in accessible locations. Last bend of stacks shall be duck foot type encased in 150mm thick of Grade 20A (Class A) concrete or bends shall be uPVC type 1000 long radius bends with adequate supporting.

2.2.2 Cleanliness

All pipes and fittings shall be thoroughly cleaned before erection and be free of scale, burrs, obstructions and other deleterious matter and their coatings shall be completely intact.

2.2.3 Installation and Workmanship

All piping shall be machine or hacksaw cut. No flame cutting is permitted except with the express permission of the M&E Engineer. All burrs on the inside of pipes shall be removed. Changes in direction shall not be made by bending pipes (except for 25mm diameter or smaller pipes) nor by fabricated bends. All piping shall be installed to avoid other services. Allowances shall be made for all minor adjustments to pipe runs etc., needed to overcome the obstructions of the building and other services, despite the fact that they may not be shown in detail on the drawings.

All fittings shall be suitable for their application, and pipes/fittings shall be supported and installed to the manufacturer's requirements/approvals.

2.2.4 Vents and Drains

Pipes shall be vented at high points with B.S.P. plugs and shall be provided with plugged drain connections at the low points. All vent pipes shall be concealed in walls, floor slabs or in ceiling spaces. All vent pipes shall extend through the roof to a height in accordance with the requirements of the local regulations and shall terminate with an approved vent cowl. Weatherproofing the roof penetration shall be done using the proprietary weathering apron.

2.2.5 Reducers

Eccentric reducers shall be used in all horizontal locations installed so that in liquid services the top is level and in gaseous service the bottom is level.

2.2.6 Pipe Jointing

- PPR Pipes: Fusion Welding

Install fittings and joints using socket-fusion, electro fusion, or butt-fusion as applicable for the fitting type. All fusion-weld joints shall be made in accordance with the pipe and fitting manufacturer's specifications and product standards.

Fusion-weld tooling, welding machines, and electro fusion devices shall be as specified by the pipe and fittings manufacturer. Prior to joining, the pipe and fittings shall be prepared in accordance with F2389 and the manufacturer's specifications. Joint preparation, setting and alignment, fusion process, cooling times and working pressure shall be in accordance with the pipe and fitting manufacturer's specifications.

- uPVC Pipes: Solvent Cement

Pipe runs shall be fabricated using cemented sockets, bushes, bends, elbows and tees but flanged or screwed joints shall be used at the connection to plant items and valves.

Sufficient additional flanged joints shall be provided to facilitate maintenance and dismantling as directed by the M&E Engineer.

If uPVC pipes are jointing with cast iron pipes, use proprietary caulking bush with rubber ring seal against the uPVC pipe, and caulked into the cast iron socket using approved caulking compound.

2.2.7 Provision for Expansion

Piping shall be installed so that it is free to expand and contract without imposing undue stresses on any branch connection or piece of equipment. Wherever possible, the advantage shall be taken of changes in direction of pipes to take up expansion and contraction due to temperature changes of the pipe and its contents.

All rigidly joined vertical pipes shall be anchored as required to control the movement of pipes due to thermal changes. One anchor shall be provided for each vertical pipe not exceeding 50 meters in length or fitted in position as indicated in the specifications, drawings to resist movement due to expansion/contraction and the weight of the pipe & its contents. Expansion joints must be provided between anchors.

Locations of expansion joints & pipe anchors shall be carefully planned to make suitable allowance for temperature variations.

2.2.8 Supports

Where supports are not detailed on the drawings, ensure that the strengths and sizes of all pipe supports are adequate in all respects. Supports shall be arranged so that the piping loads are shared by the supports so that no fixing is over-stressed. Pipe supports shall be provided, to suit the various pipework in a stable and secure manner. Pipe supports shall allow for free movement for expansion construction. Provide slide bearings to ensure free movement. Where pipe rings are used, they shall be split pattern with nut and bolts.

Pipe clamps, bands, saddles and the like shall be of 3mm minimum thickness.

Light gauge galvanized steel straps shall not be used. Provision shall be made for an expansion and contraction allowance of plus and minus 0.3mm/m of wet system pipework in order to avoid damage.

Pipe supports shall be located not more than 600mm from each change of direction.

Cast iron pipes shall have a minimum of two supports per length. Pipes joined by compression or hubless joints shall be supported by either side (within 200mm) of the joint, and lateral and axial bracing shall be provided to minimize pipe movement.

Ferrous piping shall have ferrous brackets, hot dipped galvanized when fixed inside building and stainless steel when fixed in external wall/facade of the building. For PVC tubing, the support shall be sheathed with plastic sheet or other approved soft material and copper pipes shall have brass brackets.

All pipe supports shall be fitted with PVC isolation strips, or other approved insulating material, to prevent contact between pipes and supports. Pipes supports are to be ferrous painted.

Spacing of supports shall be in accordance with the following table. In addition, provide brackets adjacent to valves, joints, changes in direction and other large items to prevent undue strain. Additional supports shall also be provided adjacent to pump connections etc.

Spacing: Spacing of supports horizontally and vertically shall not be greater than shown in the following table (all sizes in millimeters).

Pipe Size (mm)	Hanger Size (mm)	Cast Iron & Ductile Iron Pipes		Copper & Steel Pipes		uPVC & Polypropylene Pipes	
		Maximum Intervals (m)					
		Ver.	Hor.	Ver.	Hor.	Ver.	Hor.
15	10			2.1	1.5	1.2	1.0
20	10			2.1	1.5	1.2	1.0
25	10			2.1	2.1	1.2	1.0
32	10			2.1	2.1	1.2	1.0
40	10			2.7	2.1	1.2	1.0
50	10			2.7	2.7	1.2	1.0
65	12	2.5	2.5	2.7	3.6	1.2	1.0
80	12	2.5	2.5	3.6	3.6	1.2	1.2
100	16	2.5	2.5	3.6	3.6	1.2	1.5
125	16	2.5	3.0	3.6	3.6	2.0	2.0
150	19	3.5	3.0	4.2	4.2	2.5	2.5
200	22	3.5	3.0				
250	22	3.5	3.0				
300	22	3.5	3.0				

- Attachment to Steel Structure

No welding to or drilling of structural steelwork is permitted. Holes may be drilled through the back of purlins to support pipes 50mm and smaller but other means must be used to support larger pipes.

- Attachment to Concrete Structure

All pipes larger than 150mm diameter that are suspension supported shall hang from supports cast into the structure during construction. Allow for the cost of supplying all supports of an adequate size and quantity. Provide a drawing clearly indicating the location of all such supports prior to formwork being placed and allow for the cost of fixing. Check that all supports are correctly located before concrete is placed.

2.2.9 Pipe Guides and Anchors

The Subcontractor shall supply and install pipe guides in vertical pipework as specified, shown on the Specification Drawings. For pipes 100mm diameter, pipe guides shall consist of a layer of min. 8mm thick, 40 durometer neoprene waffle pattern sleeves complete with steel frame for fixing to the walls, floor support and support bracket.

For pipes above 100mm diameter, pipe guides shall consist of a riser angled frame around the pipe as shown in the specifications and drawings. Pipe risers shall be isolated from the structure by means of neoprene in shear mounts with a minimum static deflection of 6mm and bolted rigidly to the angle frame. There shall be no rigid ties or connections of pipe risers to the building structure.

Anchors shall be positioned in association with change in pipework direction and expansion compensators such as to transmit the forces due to expansion and internal pressures to the ground or structure at appropriate points. Testing shall also be taken into account when designing anchors. All details and sizes of anchors shall be submitted for approval prior to installation.

2.2.10 Sleeves

Pipe sleeves of an approved type shall be provided at all locations where pipes pass through wall, beams, and floors. Where sleeves or piping pass through reinforced concrete walls below the water table, puddle flange shall be provided. All horizontal runs through walls and structural members and vertical penetrations by risers through floors shall be sleeved.

All piping passing through a wall or floor shall be sleeved to allow freedom for expansion and contraction and other movement. Sleeves of PVC or other approved material of internal diameter at least 30mm greater than the outside diameter of pipes shall be built-in. Preferred to use

galvanized steel pipe sleeves. For floor penetration it shall end 50mm nominal proud from floor. For wall penetration, it shall be flush with wall. The space between the sleeve and pipe shall be packed with suitable ceramic fibre fireproof packing and sealed on top with polysulphide sealant which will ensure water tightness and maintain the fire rating of the works and floors.

Pipes penetrating basement floor or wall shall be cast in or otherwise set in later in blocked out penetrations of sufficient size to accept the pipe with a puddle flange and made up on both faces of the penetration with an approved expanding grout to be completely watertight on completion.

Pipes through Roofs: Where pipes pass through concrete roofs, provide and fix 450mm x 450mm x 1.8 kg lead slates and collars for pipes, the slates being sandwiched between the layers of the asphalt or membrane roofing and collars bound to the pipes with galvanized screw clips.

All galvanized steel pipes where embedded in screed, or concrete or run underground shall be coated with two coats of bituminous paint on the outside and wrapped completely round with a layer of Denso tape. Pipes bored in plaster, or brickwork structure shall be similarly bitumen coated but without tape wrapping.

2.2.11 Expansion Joints

Wherever necessary, due allowance shall be made for the expansion and contraction of pipework by change in direction of pipework, or expansion loops, whether shown on drawings or not. At building expansion joints and wherever else necessary, additional allowance shall be made by the provision of stainless steel externally pressurized type expansion compensators complete with all necessary guides etc. as recommended by the manufacturer. Each compensator shall maintain at least the same cross-sectional area as adjoining pipework for its entire length. During sectional testing, ensure that the expansion joints are adequately tied, anchored or removed to avoid damage to the bellows.

On larger diameter (150mm and above) steel, ductile and cast iron pipes, judicious use of 'dresser' couplings shall be made for connections to all plant items. Couplings shall be arranged such that torsional, coaxial and lateral stress caused by expansion and/or settlement shall not be transmitted to the flanged connections of the plant.

2.2.12 Installation of Underground Pipe Work

- **Excavation**

All excavation shall be done in a proper manner to the lines, gradients and levels indicated on the drawings. Ensure that the excavation is carried out in a safe manner and take all necessary measures to that effect such as steel sheet piling, timbering, planking and strutting. Water shall be removed by pumping and all temporary expedients required for

dealing with water shall be included in this work. Mechanical excavator may be employed only if the subsoil is suitable and with the approval of the M&E Engineer. The materials excavated from trenches shall be laid compactly beside the trench and if necessary, keep 3m clear of the trench except where in the opinion of the M&E Engineer this would so obstruct any road as to prevent the passage of traffic or pedestrians. Where pipes are not laid on concrete, the trenches as excavated shall be smooth and free from stones or other projections. Holes cut out at the joints shall be of as small a size as possible and the pipes shall have a uniform and solid bearing throughout their lengths. The trench shall be dug to within 150mm of its formation and proper grade pegs shall then be set in the bottom of the trench. The last 150mm shall be excavated manually only immediately before laying of pipes. If any part of a trench is excavated deeper than is required by error, the extra depth shall be filled up with Grade 10 concrete as directed by the M&E Engineer at no extra cost. All surplus excavated materials shall be removed from site.

Trenches for pipes shall be excavated to sufficient depth and width to enable the pipe and any specified or agreed joint, bedding, hunching and surrounding to be accommodated. Where the width of the trench is not specified, it is to be as narrow as working conditions permit. The minimum width of the trench shall be 300mm greater than the external diameter of the pipe. Extra width shall be given at all fittings to allow them to be placed, jointed and inspected. Mud, rock projections, boulders, hard sports and tree roots encountered in trench bottoms and under drainage structures shall be removed and replaced with compacted special filling material.

- **Bedding and Laying of Pipes**

Pipes shall be laid on a 75mm (minimum) thick sand bed.

Immediately following excavation of the trench, pipes shall be laid and joined to correct level and line. Brick or other hard material shall not be placed under the pipes for temporary support. Pipes shall be laid with the sockets upstream starting at the downstream end of the trench. The pipes shall be appropriately supported clear of the trench bottom. The clearance under the barrel shall be not less than the specified thickness of the bedding or surround. Pipes shall be laid so that each one is in contact with the bed throughout the length of its barrel.

Where a concrete bed, haunch or surround as specified, it shall be constructed as follows. Pipes shall be supported clear of trench bottom by means of wedges or concrete blocks or cradles padded with roofing felt and placed under the pipe immediately behind each socket. For pipes 600mm diameter and larger a similar block or cradle shall be placed

near the spigot. Clearance under the barrel shall not be less than the specified thickness of the bedding or surround. The flexibility of the pipeline shall be maintained by providing flexible joints in the concrete bed, haunch or surround corresponding to the joints in the pipeline. Such joints shall consist of 20mm gaps in the concrete filled with a soft compressible material such as fiber board or polystyrene precut to the finished profile of concrete and pipe to prevent entry of stones etc. likely to restrict the flexibility. In addition, flexible joints in concrete bed, haunch and surround shall be formed at intervals of 5,000 mm. The reinforcement, if any, shall be placed and secured in position with 50mm clearance between the transverse reinforcement and the bottom of the pipe. Reinforcement shall not pass through flexible joints.

Pipes and trench floor shall be wetted down, if necessary, and concrete carefully placed and compacted throughout the entire length of the pipes. Concreting of bed, haunch and surround to pipes shall only be commenced after interim testing to pipelines and approval of the test results.

The open ends of all pipes and connections shall be suitably covered to prevent debris, etc., entering before the joints are made.

After being joined but before being tested, pipework shall be securely anchored by means of concrete thrust blocks wherever there could be an unbalanced hydraulic thrust. Allow a Civil Professional Engineer to design and certify thrust blocks at all bends, offsets and valves of pipework whose joints are not capable of resisting the hydraulic thrust. The concrete shall be placed between the pipe and the side or end of the undisturbed trench wall; care being taken to ensure that joints are not concreted over.

The pipework including any protective system shall be inspected by the M&E Engineer before backfilling. Any defects shall be made good at no additional cost.

- Backfilling

All timber shall be removed from the excavation before or during the progress of refilling unless otherwise specified. Backfilling shall not be started for least 48 hours from the time of placing concrete beds, haunches or surrounds to pipes.

After joining the pipes, and on completion of testing of the pipelines, granular bedding material or where none is specified, the backfill material, shall be brought up equally on both sides of the pipe to the level of the center of the pipeline and then the bedding or backfill material shall be brought up to a level of 300mm, or as detailed, above the top of the pipe barrel in layers, each not more than 100mm thickness, and carefully compacted by hand for the full width of the trench.

The backfill at the sides and immediately above the pipe for a height of at least 100mm above the top of the pipe and joints shall be filled with sand thoroughly rammed around the pipe except as otherwise required by the drawings or to meet relevant public authorities' requirements.

The pipes shall be subjected to a pressure test after laying and jointing and before joints are covered with backfill. Such testing shall be carried out in the presence of the M&E Engineer. Give the M&E Engineer at least 48 hours notice of when such testing will take place.

After testing the trench shall be carefully backfilled. The first layer of filling shall be sand thoroughly rammed around the pipe. Non-metallic pipes shall have a continuous layer of bricks or concrete slabs lay over the sand before backfilling is completed.

For future location/identification, plastic marker strip appropriately labeled shall be buried 300mm above the pipe and 50mm x 50mm markers fixed flush with finished ground level above every bend and at 10m intervals along pipe route.

In verges and grass areas, the backfill above the sand may be the excavated material.

All other fillings shall be hard fill, the material and method of backfilling being in accordance with the specification for the surrounding ground. Any settlement occurring prior to the end of the Defects Notification Period shall be made good including the local resurfacing at no extra cost.

Remove all surplus excavated materials from site.

Additional Information:

For trenches in carriageway pavements the backfill material shall be brought up to formation level with 'special filling material' comprising material which is acceptable in accordance with the contract for use in the works but shall pass a 25mm BS sieve for pipes 900mm diameter or less and a 50mm sieve for pipes of larger diameter. The fraction passing 25mm or 50mm sieve shall have the following characteristics.

- ✓ Liquid limit not exceeding 35
- ✓ Plasticity index not exceeding 12
- ✓ Coefficient of uniformity shall be greater than 10
- ✓ The percentage passing a 63-micron BS sieve shall be less than 20% by weight

For trenches in other locations, special filling material up to formation level shall have the above characteristics except that it shall pass 75 mm BS sieve.

The remaining reinstatement shall be undertaken to the full width and in the materials excavated from the site but free from large, hard obstacles.

When backfilling over pipes with concrete beds or surrounds:

- ✓ Backfilling shall not be started within 48 hours of placing concrete.
- ✓ Heavy compactors shall not be used.
- ✓ Prevent traffic loads within 72 hours of placing concrete.

When backfilling over pipes not surrounded with concrete:

- ✓ Special backfilling materials shall be laid and hand compacted in 100mm layers up to 300 mm above top of pipe.
- ✓ Main backfilling material shall then be filled in and compacted in 300mm thick layers.

Temporary bridges over trenches shall be provided after backfilling to prevent heavy construction traffic damaging pipes.

No vibrating extractors shall be used to remove piles or sheet piles installed as temporary work during the construction of pipelines.

For heavy duty Sewer and drainage pipes: Provide and fix 150mm thick concrete foundations to heavy duty sewer and drainpipe, 300mm wide for 100mm diameter pipe, 450mm wide for 150mm diameter pipe and 525mm wide for 225mm diameter pipe carried up vertically to the middle of the pipe and then haunch over the crown of the pipe. If the depth to top of pipe is less than 1.0m or over 5.5m, the pipe shall be encased in 150mm concrete instead of haunching. All concrete for foundations shall be at least grade 25 unless otherwise stated. Pipe laying shall commence at the lower level of the gradient between manholes.

The pipes shall be laid with sockets leading uphill on the prepared bed concrete.

All pipes shall be kept free from earth, debris, superfluous cement and other obstructions during laying and jointing and until the completion of the works when they will be handed over in a clean and good working condition.

Where necessary due to the ground condition, tamped/bakau piles shall be provided under drain beds, manholes and inspection chambers.

2.2.13 Inspection Chambers and Manholes

The minimum internal dimensions of inspection chamber/manhole are to be 600mm x 600mm for Sewer and Storm water and 450mm x 450mm for wastewater unless otherwise specified in drawings. If the Inspection Chambers are constructed in brickwork, the outside

surface shall be finished joints and the inside surfaces rendered with sulphate resisting cement mortar 1:3, 20mm thick, steel trowelled to smooth surfaces. If they are constructed in reinforced concrete, the internal and external surfaces shall be finished smooth.

All inspection chambers, hatch boxes and sumps inside the building shall be cast in reinforced concrete, waterproofed and shall be an integral part of the building structure to be provided by the builder. Pipes laid between these inspection chambers, hatch boxes, sumps shall be permanently suspended below the floor slab.

The Sub-contractor shall submit pipe suspension details to the floor slab for Structural Engineer's approval prior to commencement of works. Notwithstanding that the structural works for such manholes and Inspection chambers shall be done by the builder, the cover, accessories, channeling and benching shall be carried out under this Subcontract.

Provide and fix 100mm, 150mm or 225mm salt glazed ware main channel to proper radius in all Inspection Chambers and Manholes with concrete benching formed with 19mm grade coarse aggregate and steel trowel with extra cement and sand to smooth surface.

Channel shall be of quality known to the trade as ordinary best quality. They shall be well-glazed, impervious free from fine cracks and other defects to BS 65 and 540.

Inspection Chambers of depth exceeding 2500mm shall be constructed of RC chamber rings with 150mm thick concrete surround. Each summit inspection chamber is to be vented to roof of building. The subcontractor is to comply with the requirements of the Relevant Authorities with whom he shall maintain a constant liaison.

All Inspection Chambers and Manholes shall be roofed with a reinforced concrete slab of minimum 150mm thickness and provided with an opening which shall be fitted with a cast iron airtight frame and cover of round, rectangular or double triangular configuration to BS EN 124. Where Inspection Chambers are located within toilets, pedestrian walkways or buildings, frames and covers shall be installed to an appropriate level to receive tiling on top to match surrounding. Two coats of black bituminous paint shall be applied to all covers and frames.

Inspection chambers and manholes greater than 2000mm depth shall be provided with step irons. Step irons to chambers shall be galvanized iron. Manhole step irons shall be malleable cast iron. Unless otherwise shown in the drawings, general purpose pattern step irons with 127mm tails shall be used in the brick walls and rounded bar pattern step irons shall be used in concrete walls. Manhole and Inspection Chamber covers and frames shall be cast iron (coated or galvanized) flat covers and frames complying with the requirements of BS EN 124. They shall be either heavy duty/medium duty or light duty as indicated in the BOQs.

2.2.14 Testing and Commissioning of Pipe Work

All piping shall be pressure tested to the M&E Engineer's satisfaction and in accordance with the requirements of the various authorities concerned. Give the M&E Engineer 48 hours notice of when such testing will take place.

Record start and finish pressures on the Pipe Test Certificate sheet available from the M&E Engineer and obtain the required witness signatures.

All piping shall be flushed clean with water or nitrogen as applicable. Strainer baskets shall be removed, cleaned and reinstalled upon completion of the cleaning process.

Disinfect potable water pipework in accordance with Authorities requirements.

The section to be tested shall be blanked off at both ends and at branches which it is desired to test separately. The blank ends and all bends, tees, etc., shall be securely strutted or otherwise prevented from movement and the pipeline shall be held by backfilling between joints. For systems which have been tested in sections, a final test of the whole system shall be carried out. All defective work shall be made good forthwith at no extra cost.

Potable water pipework systems shall be demonstrated to the M&E Engineer to work quietly and without pipe vibration, water hammer, or excessive pipe noise once the final fittings are installed and commenced.

Where units or complete installations are known to be not used or occupied immediately, such installations or part thereof shall be drained down and all water removed with the use of compressed air, isolated for future use. The purpose of this is to eliminate any detrimental effects of water stagnating in the pipe system after completion and prior to operation. Allow costs to carry out this as part of the handing over process.

- Water supply and Pumping pipelines

Before all pressure pipes (water supply and pumping lines) are concealed or insulated, hydrostatic pressure of 1.5 times the working pressure or 1050 kPa whichever is the greater and maintained for minimum 8 hours up to 24 hours unless otherwise specified. Pressure should not show a drop of more than 2% over the 24 hours test period.

For underground water service, a leakage rate of not more than 2 liters of water per centimeter of pipe diameter per 1000m of pipe per 1000 kPa of pressure is acceptable.

- Drainage pipes

All drains and piping shall be rodded prior to testing to check for straightness and obstructions. For large systems, the tests may be carried out in sections.

Water test: All drainpipes shall be subjected to a water test under a static head of not less than 1.5m of water at the upstream end of the line. There shall be no loss of head for a period

of 4 hours. The static head does not exceed 6m. Testing shall be conducted before placing concrete for hunching and encasing.

Soundness Test: The water seals of all sanitary appliances shall be fully charged and test plugs or bags inserted into the open ends of the pipework to be tested. One of the testing plugs shall be fitted with a tee piece, with a cock on each branch, one branch being connected by means of a flexible tube to a manometer. Alternatively, a flexible tube from a tee piece fitted with cocks on its other two branches can be passed through the water seal of a sanitary appliance. A manometer can be connected to one of the branches as described before. Air is pumped into the system through the other branch of the tee piece until a pressure equal to 38mm water gauge is obtained. The air inlet cock is then closed and pressure in the system should remain constant for a period of not less than 5 minutes.

Defects revealed by an air test may be located by means of a smoke test or soap solution applied to the pipe joints.

- Manholes & Inspection Chambers

All inspection chambers and manholes shall be tested for water tightness by filling with water and observing for any drop in water level over a period of at least 4 hours.

- Performance test for Drainage pipes

This test shall be performed to check the self-siphonage and induced siphonage in branch discharge pipes. In addition to check the induced siphonage and back pressure in discharge stacks. All appliances, whether discharged singly or in groups, should drain speedily, quietly and completely. To ensure that adequate water seals are retained during peak working conditions a number of appliances are discharged simultaneously. After each test, a minimum of 25mm water seal must be retained in every trap. The test must be repeated at least 3 times; the traps being recharged before each test. Refer to Table NG.1, BS EN 12056-2:2000 for number of appliances to be discharged simultaneously.

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For all tests, contractor shall submit Method Statements and obtain Engineer's approval.

2.3 Valves

2.3.1 General

Valves shall be manufactured in accordance with the manufacturer's specifications and shall comply with the performance requirements of ASTM F 2389 or CSA B137.11. The valves shall contain no rework or recycled thermoplastic materials except that generated in the manufacturer's own plant from resin of the same specification from the same raw material.

All valves located below the ground shall be provided with a cast iron Toby box or cast iron valve box or concrete valve chamber (with access cover) for access. All valves which are below ground in paved areas (bitumen, concrete, etc.) shall be provided with a heavy duty manhole cover and frame set in concrete valve chamber and flushes with finished level.

Minimum working pressure 1050 kPa or 1.5 times the maximum working pressure, whichever is greater. All fittings shall be DZR brass or gunmetal and approved for the particular application by the Local Regulation/Water Authority. No cast iron components shall be in contact with potable water.

All Valves and Fittings which are installed in Cold Water & Hot Water System should have **WRAS** certification.

All valves should be of high quality and suitable for the working pressure of the system in which they are installed.

Test cocks of 15mm diameter shall be provided in the suction and discharge pipe of all pumps whether shown or not on the drawings.

Isolating valves shall be fitted to all plant, equipment, sanitary fixtures, tanks, etc., whether shown or not on the drawings.

Regulating valves shall be fitted to all branch pipes, by-pass pipes, etc., where regulation of flow is required whether shown or not on the drawings

- Valves 65mm diameter and smaller, socket ends suitable for brazed connections each side.
- Valves 80mm diameter and larger shall have flanged ends or wafer type between flanges.

- Isolating Valves/Stop Valves

Isolating valves up to and including 65mm diameter shall be of gunmetal or bronze construction full way gate type with solid or split Disc wedge pattern to BS EN 12288. All valves are to have inside screw, non-rising stem of high tensile spindle and screwed cover. Valves are to have screwed female ends and are to be fitted with cast iron hand wheel.

Isolating valves of 80mm diameter and over shall be flanged bronze to BS EN 12288, construction with full way sluice, bronze wedge, high tensile spindle with inside screw and non-rising stem. Valves are to have bolted covers and to be fitted with cast iron hand wheel.

Stop cocks exposed to view are to be of approved design with a chromium plate easy-clean pattern and wheel head.

- Sluice Valves

Sluice valves shall be rubber bonded wedge type to BS 5163 where required by the Local Standard/Water Authority. Otherwise, non-rubber bonded wedge type is acceptable. Wherever possible, one brand of valves shall be used throughout the entire project for all sizes. Valves of 80mm diameter and larger shall be with epoxy lined cast iron body with stainless steel, bronze or epoxy coated cast iron, blade.

- Regulating Valves

Regulation valves shall be globe type to BS EN 12288 and conform to the Local Standard/Water Authority's Standard of Water Fittings and requirements. Wherever possible, one brand of valves shall be used throughout the entire project for all sizes.

- 65mm diameter and smaller: Globe-Bronze, renewable composition disc, screwed bonnet.
- 80mm diameter and larger: Butterfly-wafer type, iron body stainless steel or bronze disc, wrench operated.

- Globe Valves

Globe valves up to and include 80mm diameter shall have gunmetal body with female connections to BS 5154. Valves 100mm diameter and above shall be of flanged bronze type. Valves shall have parabolic shaped disc to give a 'straight line' characteristic of water flow to spindle lift. All valves shall be block shield.

- Non-Return or Check Valves

Check valves shall be to BS 5153 or BS EN 12288 and conform to the Local Standard/Water Authority's Standard of Water Fittings and requirements. Wherever possible, one brand of valves shall be used throughout the entire project for all sizes. Check valves on the discharge side of all pump outlets shall be with spring loaded non-slamming type.

- 50mm diameter and smaller: DZR brass or stainless steel, swing, renewable composition disc, screwed bonnet, brazed ends.
- 65mm diameter and larger: Wafer type, epoxy coated cast iron body, spring loaded dual plate type, stainless steel or bronze plates, and resilient lined casing. Non-lined check valves are not acceptable.

- **Pressure Reducing Valves**

Wherever necessary, pressure reducing valves shall be installed in the hot and cold water systems, whether or not shown on drawings in order to maintain pressure requirements at water fittings/equipment. Wherever possible, one brand of valves shall be used throughout the entire project for all sizes.

Each valve shall be preceded by a gauge cock, strainer and isolating valve or as per the detailed drawings/BOQs provided. Pressure gauges complete with cocks and rod pointers shall be located on the upstream and downstream side of the valve. Anyway, provisions should be kept to fix and monitor the pressure levels both downstream and upstream sides of the pressure reducing valve.

- 65mm diameter and smaller: Direct acting type with adjustable pressure, bronze body
- 80mm diameter and larger: Pilot operated type with adjustable pressure, bronze or stainless-steel body

Valves components shall be removable for repairs with the valve body still-in-line.

Valves are to be equipped with an inlet Y-strainer to protect valve components.

Pressure reducing valves shall maintain a constant outlet pressure independent of outlet flow rate or inlet pressure fluctuations.

- **Tank Make-up Ball Float Valves**

Float operated valves shall comply with BS 1212. Wherever possible, one brand of valves shall be used throughout the entire project for all sizes. Valves shall be of bronze body direct acting float operated type for sizes up to 80mm and of pilot operated type with stainless steel body and bronze trim for sizes 100mm and above. Pilot operated float valves shall only be used for domestic water service if: The entire pilot operated ball float valve is installed within the potable water storage tank; or where all components of the pilot operated ball float valves with the exception of the main valve/body are installed within the potable water storage tanks, any opening in the tank linking the components within the tank to the main valve/body shall be completely secured/sealed with fixed joint/fitting/adaptor.

In addition, the pilot operated ball float valves shall be tested to meet the project requirements and up to the Engineer's satisfaction.

The Contractor shall be responsible to establish that the pressure at the inlet of the float valve is within the acceptable range.

Valve components shall be removable for repairs with the valve body still-in-line. Valves are to be equipped with an inlet Y-strainer to protect valve components. Strainer up to and including 80mm diameter shall be of screwed end bronze type. Strainer of 100mm diameter and above shall be of cast iron and flanged type.

Float operated valves shall be hydraulically operated, diaphragm actuated in either globe or angle pattern to suit site conditions.

The float and stem assembly shall be sufficiently rigidly supported to preclude binding or deflection. The high/low pre-set levels shall be fully adjustable to suit installation conditions. All wetted parts shall be of 316 stainless steel construction with copper float. The valve shall open when the float is at low liquid level and close drip-tight at high level. A stilling well shall be installed around the float to minimize effects of turbulence and ripples.

- Automatic Make-up Float Valves

Where there is insufficient free board depth to install the ball float valves, the automatic float valve shall be used. The valve shall be fluid actuated and have a single moving assembly. The valve shall open wide when the float is at a low liquid level and shall close drip-tight when the float is at high liquid level. The float pilot shall have a vertical rod and adjustable high and low float stops for selectable drop in level control.

Pilot operated float valves shall not be used for domestic water service.

- Pressure Gauges

Pressure gauges shall be of the 100mm diameter brass cased type with flangeless face. These shall be designed for pipe mounting and be calibrated in kPa. All pressure gauges shall be of the Bourdon tube type and selected for normal operating point to be at about mid-point of the scale and with maximum scale value of the order of 200 per cent of the maximum working pressure. All pressure gauges shall be provided with suitable gauge cocks of not less than 6.25mm and snubbers to prevent vibration of the needles. Pressure gauges shall conform to BS EN 837.

Pressure gauges shall have scales with divisions not exceeding 20 kPa for a maximum scale value of 1000 kPa, not exceeding 50 kPa for maximum scale valves in excess of 1600 kPa.

Provide pressure gauge at suction and delivery of every pump.

- Drain Cocks

Drain cocks must be provided wherever required to ensure that every section of pipework can be drained. In particular cocks must be provided on the 'dead' side of non-return valves and isolating valves located on mains.

Sizes of drain cocks are to be as follows:

Pipes 100mm diameter and above : 20 mm

Pipes 80mm diameter and below : 15 mm

All cocks are to be gland-pattern with hose union.

- Strainers

Strainers shall be installed on all pumps and equipment and control valves to prevent damage or malfunction. Strainers are "Y" pattern shall conform to the Local Standard/Water Authority's Standard of Water Fittings and requirements. Wherever possible, one brand of valves shall be used throughout the entire project for all sizes.

- 65mm diameter and smaller: Bronze, screwed ends, screwed cap, stainless steel screen
- 80mm diameter and larger: Bronze or stainless steel, flanged ends, bolted cover, stainless steel screen. 150mm and larger provide permanently installed blow down connection with stop valve

- Shock Absorbers

Wherever necessary, shock absorbers or water hammer arrestors shall be installed in the hot and cold water systems, including Water Transfer pump headers (each) whether or not shown on drawings. The Contractor shall ensure that the shock absorbers provided are suitable for the systems and shall be sized to overcome water hammer and surge in the systems.

Shock absorbers shall be of the permanently sealed, gas filled, non-mechanical type. Calculations for the sizing of the shock absorber shall be submitted for approval.

- Steel Flexible Pipeline Connectors

All pipe connectors to pump set and to any equipment subjected to vibration shall be done by means of flexible pipeline connectors. Connectors shall be proprietary type with bellows of stainless steel mesh reinforced synthetic rubber. Unless specially permitted by the M&E Engineer, rigid connectors between pipelines and equipment will not be accepted.

- 50mm diameter and smaller: Flanged or union end fittings

- Larger than 50mm diameter: Flanged ends with control bolts to limit elongation

Neoprene or spring hangers/spring suspension brackets of approved manufacturer shall be used for supporting pump delivery.

- Rubber Flexible Pipeline Connectors

Connectors shall be proprietary type with bellows of nylon reinforced synthetic rubber, and shall conform to the Local Standard/Water Authority's Standard of Water Fittings and requirements.

- 65mm diameter and smaller: Flanged or union end fittings
- 80mm diameter and larger: Flanged ends with control bolt to limit elongation

- Traps

Traps are to be selected for particular fittings and located in accordance with the details given on the drawings. Trap bore sizes, unless otherwise specified, shall be the same as the corresponding soil or waste branch bore size. The seal of the trap shall be 75mm deep minimum and shall be of the anti-symphonic type.

Floor trap/ waste shall be uPVC or ABS with SS cover grating. Anti-mosquito device shall be provided where necessary. The covers for floor traps shall be of stainless type.

This also applies to floor waste covers.

Unless otherwise noted on the drawings, traps shall be as follows.

- Wash basins & sinks: shall be fitted with a 75mm deep seal bottle or P trap. Where these are normally visible, they shall be chromium plated.
- Urinals: Each wall hung urinal bowl is to be fitted with a 32mm diameter bore, 75mm (minimum) deep seal bottle trap. Where these are normally visible, they shall be chromium plated.

2.4 Water Meters

Water meters in mains, sub mains and consumer points shall conform to the Local standards/Water Authority's standard and be suitable to the system pressure requirement. All water meters shall be with WRAS certification and the minimum accuracy class of Class B or Class 1 or R80. Water meters shall be coming with in-built non-return valve, if not a separate non-return valve shall be provided at downstream of the meter.

2.5 System Sterilization

The complete domestic cold water (potable water) supply system shall be cleaned and sterilized in accordance with Local/International standards. Contractor shall submit a Method Statement for the said work and obtain Engineer's approval.

Furnish the M&E Engineer a certificate evidencing that this sterilization has been carried out. Submit test reports from an approved laboratory on the water quality analysis, which shall include pH, residual chlorine bacteria, copper and iron levels. Obtain certificate from pipe and pump suppliers upon completion.

2.6 Guarantee

Provide a guarantee on all potable water system components that the pipework system or any equipment, fittings, components or pipework will not corrode within 5 years. Any components which corrode resulting in water discoloration during this time shall be replaced at no cost to the owner.

3. Irrigation System

An irrigation system shall be provided for watering the plants within the plant troughs. The pipe work shall terminate at strategic points of the landscape area and be terminated with duplicated outlets, including a connection for solenoid valve of the automatic drip irrigation system and a bib tap for manual watering. uPVC PNT11 pipe work shall be used for main lines of the irrigation system. Low Density Polyethylene (LDPE) pipes for drip irrigation system.

4. Water Storage Tanks

For all water storage tanks; Infill, draw-off, warning and drain-off connection inverts shall be in accordance with the Water Authority requirements, and so as to achieve the effective capacity stated on the drawings.

Piping and flange connections to tank shall be in accordance with the manufacturer's recommendations, with intake and draw off connections on opposite sides or diametrically opposed to prevent stagnation of water, as required by Water Authority.

4.1 Underground Water Sump

Underground sump shall be Reinforced Cement Concrete (RCC) with a single compartment. It shall be constructed with provisions of pipe sleeves for all services, float switches/level controllers, ball float valve, drain pit, overflow pipeline, provisions for electrical controlling. Sump shall be accessible through access openings with double protected type double

seal manhole covers with rubber beading. Two numbers of access openings shall be provided. Galvanized mild steel or SS rungs shall be provided for access. Vent pipe including cowls shall also be provided. Tank shall be constructed with approved sealed materials for holes, construction joints, water bar, water proofing etc., as per the structural engineer's instructions.

5. Pumps

5.1 General

Duties of pumps as given in the equipment schedules/ drawings / BOQs are for general guidance. Pump head shall be selected based on the available water supply pressure from the city water supply at the building. The Contractor must check, submit detailed hydraulic calculation and reconfirm such against the equipment / pipework they proposed and shall correct such where necessary prior to ordering.

The pumps shall be of adequate strength to withstand the hydraulic and other forces encountered but, in any case, shall be capable of withstanding a minimum hydrostatic test pressure of 1.5 times the working pressure or a minimum 150 psi or as specified elsewhere, whichever is the higher.

The pump shall be selected for an operating flow and pressure as shown on the drawing. The pump efficiency should not be less than 65% at the design point.

Pump curves with the operating point marked on shall be submitted for approval before the pumps are ordered.

The pump casing shall be of adequate strength to withstand the pressure in the system (1.5 times working) or a minimum of 150 psi whichever is greater.

Pump speed: Pumps shall be selected for an impeller speed of 1450rpm or 2900rpm unless otherwise indicated on the equipment schedule. All pumps shall be commercially silent in operation.

Pump characteristic curves: The Contractor shall submit for the approval of the Consultant, characteristic curve for each of the pumps offered. The operating conditions shall be indicated. Pumps shall be selected to operate at mid-range of the characteristic curves.

Valves & Accessories: Each pump shall be fitted with valves to enable it to be isolated, and in addition, where shown on the drawings, a check/ non-return valve shall be fitted in each pump discharge.

All pumps shall be fitted with an air-cock and drain plug. Each pump shall have a pressure gauge for suction and delivery connections. Gauges shall have 150mm diameter dial and of Bourdon type with copper syphon. Gauges shall be selected for the normal operating range and dial

calibrations shall not exceed twice the normal working pressure. Pressure gauge piping shall be copper comprising a loop syphon at the junction to the gauge and each gauge shall be supplied through 12mm diameter brass pig tail and pet cock drains shall be piped to floor drain or channel. Gland drains shall be provided in each pump packing gland with suitable nipple/ outlet for copper/ PVC pipe to be connected. All drains shall have a minimum internal bore of 15mm diameter and arranged in a proper pattern for piping the same to the channels or floor outlets provided inside the pump room.

Where necessary, an automatic air relief valve shall be fitted in the pump to purge any air likely to be trapped inside the pump casing. Suitable fittings shall be used for such connection and the relief valve shall not discharge at a location directly over or near to the pump motor or any other electrical equipment.

Flexible couplings: The Contractor is to supply and install flexible pipe connectors of minimum 450mm long at the pump suction and discharge of each pump. All the flexible pipe connectors are to have flanged ends and must be suitable for the conveying medium and testing pressure of the systems concerned.

- On suction of all pumps: All stainless steel construction externally braided, double flanged, flexible hose, one for each pump, full line size, rated 700 kPa minimum working pressure. Hose length to be chosen to give lateral movement of +/- 6mm.
- On discharge of all pumps: All stainless steel construction externally braided, double flanged, flexible hose, one for each pump, full line size, rated 2,500 kPa minimum or 1.5 times working pressure.

All exposed shafts, couplings and moving parts of pumps shall be provided with suitable galvanized angle iron wire mesh guards which shall be easily removable; and shall be provided with lifting handles. Care shall be taken that these guards do not cause 'Ringing' sound and or vibrate so causing noise.

An identification plate shall be fixed to each pump unit. This plate shall include full detail and diameter of the impeller installed, pump size, model and serial number, rpm, amps, etc., pump head and delivery for the duty specified and lubricant required.

5.2 Hydro-Pneumatic Booster Pumps

Water pumps shall be centrifugal with stainless steel casing, bronze or stainless steel impeller, stainless steel shaft, mechanical seal and grease lubricated ball or water lubricated ceramic/tungsten carbide bearings. Provide manual air vent on pump casing. Direct coupled through flexible coupling to 400 volt A.C. 3 phase non-overloading T.E.F.C. motor corrected to

0.90 power factors. Motors over 7kW shall have thermistor protection. Motor and pump shall be mounted on common base together with coupling guard. Provide plinth and inertia block complete with anti-vibration mountings with an isolation efficiency of 92%.

Select pump so that the required impeller is not the largest that can be fitted and duty point is in middle of pump curve. Capacity and operating pressure range shall be as indicated in the equipment schedule, drawings or BOQs.

Pumps shall be selected at 1450rpm or 2900rpm (Nominal) unless otherwise specified in the equipment schedule. Submit pump curves with impeller size and the duty point marked on. Pumps shall be on duty + standby basis, diaphragm pressure tank and associated pressure controls pipework and fittings, supplied as a complete unit from one manufacturer.

Pipework and fittings shall be either stainless steel or alternatively resiliently epoxy lined GI pipe, screwed or flanged and conform to the Water Authority's Standard of Water Fittings and requirements.

The maximum capacity and operating pressure range of the set shall be as indicated in the equipment schedule, drawings or in BOQs.

Pumps shall ensure adequate pressure differential for cut in and cut out.

Parallel packaged variable speed unitary pump sets complete with integrated controller, pressure tank and associated accessories may be considered as an alternative. If this option is offered, at least one spare pump unit must be provided in the package which will allow the package to run at the rated capacity when one pump is out for maintenance.

Pressure tank should be suitable for an operating pressure of twice the scheduled maximum working pressure. Tank shall be fitted with a butyl-rubber air/water separating diaphragm and shall comply with SS375. Submit full details of tank construction and provisions for corrosion protection.

The pump set shall be designed to ensure that the frequency of pump starts is 10 starts per hour or less under any draw off rate from zero up to the maximum scheduled flow rate.

Pressure controls shall be set to the pressures indicated in the equipment schedule, drawings and shall be adjustable.

A hydro-pneumatic tank shall be provided to store water under pressure to increase the duration between pump starts.

All wetted parts of the pumps shall be complied with WRAS certification or shall be suitable for potable water supply requirements.

5.3 Submersible Pumps for Sewerage and or Wastewater Collection Pits

Submersible pumps supplied shall be of vertical centrifugal type with cast iron or cast steel casings, cast iron non-clog impellers and stainless steel shafts with a speed not exceeding 2900 rpm. Double mechanical seal of ceramic shall be provided. The pump shall be designed for permanent installation in a sump such that the pump can be slide down along guide bars and connected automatically to a discharge connection.

If the weight of any pump exceeds 20 kg it shall be pull fixing type, complete with steel guide rails, pull chains, duck foot discharge bends with quick release low level couplings and discharge pipes of correct sizes rise above pits.

Each pump shall be provided with a pressure gauge, a check valve, a gate valve and a flow switch at the discharge end. A strainer of metal screen shall be fitted to the suction end.

The pump set motors shall be of submersible type with cast iron or cast steel enclosures suitable for operating on single phase 230V or 3 phase 400V 50 Hz electrical supply.

The pump motor shall be squirrel-cage type with Class F insulation and operation at speed not exceeding 2900 rpm. Output selected to have 20% margin over the required kW of the sump.

In addition, the following accessories shall be provided: Automatic control, level regulators with reference cable, AC alarm bell, cable holders, upper and lower guide holders for discharge connection, stainless steel guide bar for the pump matching inclined boltless flange for quick lifting, lifting chain.

They shall be supplied complete with multi-core heavy duty flexible cables with tough rubber outer sheaths of sufficient length for connection to the control panel through weatherproof plugs and sockets.

Automatic start/stop of pump sets shall be remotely controlled by means of submersible totally enclosed mercury float switches operating on extra low voltage supply.

The electrical requirements for the pump motor and wiring shall be as specified in clause on Electrical Works.

Bearing Life: Bearings installed in rotating equipment e.g. pumps shall have a L10 design life of 100,000 hours unless otherwise noted. Upon commissioning the supplier of equipment shall certify that the installation is in accordance with the recommended requirements e.g. in terms of alignment etc., and then guarantee the bearing life accordingly.

5.4 Pump Installation

Each pump and motor combination shall be mounted on an inertia block constructed of reinforced concrete within a steel channel frame. Weight of the block shall be not less than 1.5

times the weight of the pump set. Pump base shall be supported by Vibration Isolators, comprised of springs and neoprene pads mounted in series. The inertia block shall rest on vibration isolators which are located at the four corners, and which are in turn mounted on a 150mm high plinth. The springs shall have 50% overload capacity before reaching the fully compressed position and minimum 25mm static deflection.

Each pump installation shall consist of isolating valve pressure gauge and strainer on the suction side and a check valve, isolating/regulating valve and pressure gauge on the discharge. Pressure gauges shall be installed at the same height. A long radius bend and eccentric reduce shall be used at the pump intake (installed top level) while a concentric gradual enlarger shall be used on the pump discharge.

The installation, alignment, testing and lubrication shall conform to the manufacturer's specification. Machine bolts, nuts and keys shall be coated with a mixture of molybdenum disulfide and oil before being assembled.

The inside to the pumps shall be examined, foreign matter removed, and any defects reported to the M&E Engineer.

The levelling shall be done with packing plates and shim. Jack screws may be used for rough alignment only and must be backed-off or removed after the permanent packing plates and grout have been installed. The size of the packing and shims shall be large enough to provide adequate bearing on the concrete. Solid shims shall be used wherever possible. Wedges shall not be used as shims. Packing and shims shall be placed on both sides of the anchor bolts. Where the bolt is mounted in a pocket the packings and shims shall be placed as close to the bolts as possible, leaving sufficient space for the introduction of grout into the anchor bolt.

Install all piping and attach to the equipment, ensuring that the piping places no strain on the equipment.

The booster set shall be mounted on a purpose made steel frame with adequate anti-vibration mounts and flexible couplings to prevent transmission of vibration to the building structure or service pipework.

Bearing Life: Bearings installed in rotating equipment e.g. pumps shall have a L10 design life of 100,000 hours unless otherwise noted. Upon commissioning the supplier of equipment shall certify that the installation is in accordance with the recommended requirements e.g. in terms of alignment etc., and then guarantee the bearing life accordingly.

6. Sanitary Fittings

6.1 General

Sanitary fittings will be supplied by a nominated supplier unless otherwise stated. Allow to connect and install the number of fittings as shown in the Drawings and in compliance with the following. All sanitary fittings shall be approved by the Architect and shall be installed as per the detailed architectural drawings.

All sanitary fittings shall be low flow type.

The Contractor is responsible for setting all fixtures in their respective positions.

All sanitary fixture shall be completed with all required accessories, supports and fixings, and where applicable, with plug and washer. All fixtures shall be securely and neatly fixed into position and connected to services as required, strictly in accordance with the requirement so the relevant Authorities and the manufacturer's recommendations and instructions.

Where possible, all fixing bolts, screws, etc. shall be concealed from sight and galvanized. Fixings which are exposed to view shall be chromium plated. Where fixtures are required to be supported on timber and metal stud wall framing, the Contractor shall provide and fix backing plates drilled for bolt fixing of fixtures, securely bolted or screwed to framing.

All fixtures shall be adequately protected from damage until all painting, cleaning, etc., is completed. Fixtures shall be handed over in an unmarked condition.

Recommended brands for sanitary fittings are **American Standard/ TOTO/Duravit/Vitra or equivalent.**

6.2 Installation

Installation shall be carried out by skilled labour and shall be in accordance with best modern trade practice.

- Pedestal Water Closet

Cistern shall be located as close to wall as possible and securely fastened by bolts. All piping shall be concealed with only the isolating valve exposed. Isolating valve shall be chromed finish. Flush pipe connection shall be straight and not less than 25mm in diameter. Flush pipe shall be concealed in wall unless otherwise stated.

- Wash Basins

All washbasins shall be securely installed to the wall or table. All supply and discharge pipes shall be concealed as far as possible. Discharge from wash basin shall be completed with trap and connected to pipe in wall with flange. All exposed portions of piping and fittings shall be chromed.

In addition, fittings shall be approved for use in water systems shall conform to the Water Authority's Standard of Water Fittings and requirements, by the local Water Authority and any other relevant authorities.

- Other Sanitary Fixtures and Fittings

All other sanitary fixtures and fittings shall be properly installed and fastened with the highest standard of workmanship. Allow to take possession of all fittings from the Contractor and store and protect on site, deliver to the point of installation and install in accordance with the manufacturer's recommendation to the satisfaction of the Engineer.

7. Noise & Vibration Control

This section covers the general requirements that constitute the attainment of an acoustic comfortable environment within the building. The requirements stipulated in this part of the Specification shall be in addition to any other requirements which have already been specified elsewhere. It is the intent of this Specification that noise levels due to mechanical equipment and related services will be controlled to the Design Objectives stated herein, in all occupied areas.

The requirement specified is considered to be the minimum precautions necessary to achieve these objectives. The entire installation shall operate without objectionable noise and vibration as determined by the Engineer.

The subcontractor shall engineer his design and installation with due considerations to vibration, vibration-induced noise, airborne noise via ductwork and all air supply and return paths, including the control of all noise breakout via ducts and associated fittings.

The subcontractor should bring to the Engineer's attention should any of the requirements, in his opinion, not be attainable. Otherwise, the subcontractor shall guarantee that the equipment will operate within the criteria or bear all costs of remedial work to achieve the Design Objectives.

Machinery and equipment shall be installed so as to ensure that the transmission of tactile and audible vibration to the building due to the operation of that machinery and equipment and/or its connection to pipework, ductwork or conduits, is reduced to a practical minimum.

All rotating parts shall be balanced statically and dynamically to recognized standards.

All rotating parts, or machinery which contains rotating parts, shall be isolated from the building structure via anti-vibration isolators.

Inertia bases shall be provided for machines with large, out-of-balance forces, such as internal combustion engines, air compressors, reciprocating refrigeration compressors, pumps and high-pressure fans.

Reinforced concrete housekeeping pads, at least 100mm thick, shall be provided below all major mechanical and electrical equipment which is floor supported.

Installation of vibration and noise control equipment, including spring hangers, shall not obstruct proper equipment access for maintenance.

Design Objectives:

The requirements based on the usage of the spaces in the building are as follows.

Space	Maximum Noise Criteria (NC) in dBA
Corridors, Main entrance lobby, Lift lobby	45
Toilets	45
Offices	40
Staircases, Fire lobbies	50
Lift lobbies at carpark floors	45
Carparks	50
All other areas	45
Plantrooms	
Lift motor room	80
Pump room	85
Other plantrooms	78

All these specified criteria shall apply to all areas as measured at a level 1.5m above the floor. Where AHU rooms are encountered, the measurement shall be at similar height from the floor but at not less than 0.8m and not more than 1.5m from the AHU room walls. Where fan coil units are encountered, the highest noise levels measured under the units will only be recorded. Where a dispute arises over the classification of any area the M&E Engineer's determination shall be final.

The subcontractor shall install all noise-generating equipment and systems based on the above criteria. When the measured noise is rumbling, tonal or groaning the measured NC shall be read as plotted NC+5. When the emitted noise from any equipment carries tonal, rumbling or

groaning content, the plotted NC must be 7dB lower than the specified criteria to be considered as meeting the criteria.

8. Electrical Works

8.1 General

This section of the subcontract includes the supply, installation, painting, wiring, termination, testing and commissioning of all electrical equipment and controls necessary for the proper functioning of the works of this subcontract, and in particular the following:

- All control panel and all wiring from these control panels to equipment
- Wiring from distribution boards or local isolators provided by the electrical services subcontractor to equipment
- Earthing

The subcontractor shall supply, install and connect all earth continuity wiring for effective earthings of the whole electrical installation under this scope in accordance with the requirement of the British Standard (BS 7671) and to the Requirements of the Local Authorities.

All points and equipment shall be earthed with the appropriate circuit protective conductor (cpc), the minimum size of which shall be in accordance with the requirements of BS7671.

All final circuit protective conductors shall terminate at their respective board's earthing bar.

All electrical controls including sensors, relays, contactors, protection gear and associated control wiring.

Refer to the drawings and the rest of the specifications for interfaces between this subcontract and other subcontracts.

The subcontractor shall allow fully in his Tender Price for attendance during the commissioning of all equipment involved with the electrical and control installation to ensure optimum performance of the overall system, and for attendance on other parties involved in this subcontract control and electrical system or otherwise.

All electrical work shall comply with the latest IEE Wiring Regulations and all the amendments thereto.

All cables shall be PVC, PVC/PVC, PVC/XLPE or PVC/SWA/PVC cables specified as per tender drawing.

All cables for main power shall be of a size capable of carrying the planned load in accordance with the relevant Code of Practice, using the appropriate derating factors for temperature and site conditions and taking into consideration the permissible voltage drop.

There shall, as far as possible, be no joints in cables between terminations. Where joints are required due to long runs exceeding 100 meters, appropriate jointing boxes specifically designed for this purpose shall be used. No reduction of the strands for this purpose shall be allowed. No reduction of the strands forming the conductors will be allowed at switch or other terminals, but all the strands shall be efficiently secured by screws, nuts and washers or other approved means. All electrical equipment shall be fully tropicalized.

All control circuits shall be protected by fuses or equivalent means independent of the protection for the main circuits. All control circuit wires shall be terminated by soldering or clamping in such a way that the wires are not damaged. Accessible terminals suitably marked shall be provided for the attachment of incoming and outgoing cables.

All motors and other items of controlled equipment shall be provided with breakers, starters, contactors, isolators, time switches, timers, and with automatic and/or manual controls etc., to form a complete working system.

The electricity supply shall be nominal 400V/230V, 3 phase 4 wires, 50Hz operating with a solidly earthed neutral.

8.2 Control Panels

8.2.1 General Requirements

The control panel shall be, totally enclosed, wall or floor mounted, extensible, flush fronted and of the heavy duty industrial type.

The switchboard shall be constructed without any sag and deformation and shall be capable as a whole of withstanding without damages the electrical, mechanical and thermal stresses likely to be experienced under the short circuit current as indicated on the drawings. All components shall be suitable for indoor use under tropical conditions. The general equipment arrangement of the switchboard shall be as indicated in the drawings. This, however, shall not restrict the manufacturers from submitting alternative arrangements, but will be subjected to the M&E Engineer's approval.

The cold water pump control panel shall be of IP55 construction and shall have the following features and controls.

- ✓ On-off isolators and residual current device (RCD) breaker. For pumps larger than 10 kW an adjustable time delay and sensitivity earth leakage relay shall be used.

- ✓ Separate power and control MCB for each pump set
- ✓ Labeling: "Pump no. 1", "Pump no. 2" etc.
- ✓ Auto/off/manual selector switch for duty and standby pump
- ✓ Phase indicator lights
- ✓ Pump run and fail indicators
- ✓ Audible and visual warning for pump fail and low air pressure in hydro pneumatic tank
- ✓ Alarm mute and reset button
- ✓ Digital Voltmeter and ammeter c/w a selector switch
- ✓ Overload trip device with single phasing protection capability
- ✓ Manual start and stop push buttons
- ✓ alternating operation mechanism
- ✓ All rating of contactors, relays, etc. must be at least 130% higher than the max. full load conditions
- ✓ Hour run meters for each pump
- ✓ Dry running protection

Automatic control devices shall be provided for changeover of 'leading' to 'lagging' pump and vice versa, after each pump shut off, in order to equalize usage of both pumps.

8.2.2 Construction

Each cubicle framework shall be fabricated from rolled steel angle sections and shall be self-supporting when assembled, of standard size, uniform in height and depth. The cubicle panel shall be fabricated from minimum 1.6mm thick sheet steel with turned edges to the front panels and so framed as to provide a clean, flush and rigid construction without welded cross-struts. After fabrication the cabinet shall be thoroughly rubbed down and treated with an approved rust inhibiting primer.

Proper and adequate ventilations shall be provided to each cubicle such that the ambient air temperature within the cubicle, with the breaker/equipment dissipating the heat at rated current, shall not exceed 40°C under all normal operating conditions.

Mechanical forced cooling shall be used where necessary. The cost of such provisions is deemed to be included in the tender price.

Rear and side panels shall be fixed with self-attached screw and of door panel type.

Full access shall be provided to control equipment inside cubicles by means of suitable doors with concealed type hinges. Latching bars shall be of a substantial cross-section and fitted with adequate guides to prevent distortion during operation.

The exterior surface of all cubicles shall be finished semi-gloss grey unless otherwise instructed by the M&E Engineer except those parts normally left bright which shall be cadmium plated and operating parts finished matt black.

The interior of each cubicle shall be finished matt white and shall be dust, insect and vermin proof. The interior of each piece of equipment shall be clearly marked to show the phases. Either coloured plastic discs screwed to fixed components or identification by means of coloured plastic sleeving or phase labelling shall be employed. Plastic tape will not be permitted.

Insulation barriers and shrouds shall be provided around busbars and terminals so that it is possible to work on a dead circuit while the adjacent circuits are still live and to avoid accidental contact.

The control panel shall be factory assembled and tested before delivery to site in sections for installation.

8.2.3 Equipment Mounting

All switchgear shall be mounted on angle steel supports and fitted with escutcheon plates. Fuses shall be mounted on insulating panels fixed to the cubicle framing with mild steel brackets.

Instruments, indicating lights, rotary switches, etc., shall be mounted directly on a fixed fascia panel suitably stiffened to hold them firmly under all conditions of operation.

Relays, contactors, time switches etc. shall be mounted in a separate section or panel away from the power circuits.

8.2.4 Meters & Instruments

Meters, instruments and relays for external panel mounting shall be of flush pattern, with square escutcheon plates finished matt black. Indicating instruments shall comply with BS 89 and/or IEC 51, IEC 414, IEC 529. They shall be of accuracy Class 1. The scale shall be of 90 degree with external zero adjustment. Integrating meters shall comply with BS 5685. Kwh meter shall be of direct reading type.

Instruments, meters and relays located on the front of the switchboard shall be so positioned that as far as possible, each instrument, meter and relay is adjacent to the unit with which it is associated. Meter panels shall be hinged to provide ready access to connections and small wiring shall be enclosed in flexible plastic conduit. All meters and instruments shall be fully

tropicalized. All terminals shall be completely insulated and potential circuits shall be suitably fused.

Removable or hinged covers shall be provided with dust exclusion gaskets. Protective instruments shall be provided with provision for locking to prevent unauthorized adjustments to the settings. Where vibration is present arising from electro-mechanical devices in the vicinity, the meter/instruments shall be mounted on vibration absorbing material to prevent malfunctioning of the devices.

Voltmeters shall be provided with selector switches for phase-to-phase and phase-to-neutral voltage indication

Ammeters shall be provided with selector switches for indication of all phase currents.

8.2.5 Indicator Lamps

Indicator lamps utilized in switchboards and distribution boards shall be of the transformer type, fitted with coloured lens and flush mounted in door panels. Double filament long life low voltage lamps of suitable voltage rating shall be used.

Indicator lamps utilized in switchboards and distribution boards shall be of the transformer type, fitted with transparent lens and flush mounted in door panels. Double filament long life low voltage lamps of suitable voltage rating shall be used.

Indicator lamps used to indicate the 'Phase' of the 3-phase supply shall have transparent to indicate L1 Phase, L2 Phase and L3 Phase respectively. For indication of motor operating status, coloured lens of indicator lamps shall be green for indicating 'motor running', amber for 'motor tripped' and red for 'motor stopped' conditions. For indicating operation of contactors other than motor starting contactors, indicator lens shall be of green colour to indicate 'contactor closed' condition. Unless otherwise specified, each lamp shall be provided with its own protection cut-out fitted with a 2A HRC fuse link.

The indicator lamps shall be rated for 240 volts (+) or (-) 10%, 50Hz operations. Unless otherwise stated neon indicator lamps shall not be used.

8.2.6 Contactors

Contactors shall comply with BS775 ratings mechanical duty Class II and making and breaking category AC3. All contactors shall be sized for 3 million operations at rated motor load. Contacts shall be renewable butt-type solid copper hard silver faced, fully shrouded and the design shall be such as to ensure effective freedom from contact bounce and sticking of the fixed and moving positions of the magnet assembly.

Contactor's magnetic coils shall be fully tropicalized and wound for continuous operation at phase voltage $\pm 15\%$ with Class "B" insulation to BS 2613. Magnets shall be fabricated from silicon alloy rivetted electrical steel sheet with shaded pole and magnet/armature assemblies shall be fully floating and self-aligning. No audible humming noise shall be heard from the contactor at all times. Arc chutes and magnetic blowout coils shall be fitted to the larger sizes as necessary.

8.2.7 Overload Protection Devices

All overload protection devices shall provide effective overload protection to the motors and shall be of thermal, ambient temperature compensated inverse time characteristic type with overload protection devices on all phases with manual reset. Motors over 7kW shall be fitted with thermistor protection in the windings.

For chiller motors, thermal-magnetic overload protection device shall be provided. The thermal-magnetic overload protection device shall be of adjustable type to suit the equipment rating and starting characteristics.

8.2.8 Terminal Blocks for Control Wiring

Terminal blocks shall be mounted on DIN 35 "OMEGA" rails with partitions, end plates and end brackets provided as necessary. The terminal blocks shall be rated at no less than 500V and 20A and shall be interruptible. The connectors should be suitable for both flexible and solid wires and designed to ensure good electrical connection.

Markers shall be provided on both sides of the terminal block to uniquely identify each terminal block and wire.

8.2.9 Drawings

A drawing showing the type, arrangement, actual dimensions and assembly of the switchboard shall be submitted to the M&E Engineer for approval prior to fabrication and installation. A neat "As-Built" drawing showing the schematic wiring diagram of the switchboard arrangement shall be supplied and framed behind glass by the switchboard manufacturer to be displayed in the main switch room. Drawings shall be permanent A1 size.

8.2.10 Labels

Labels of approved pattern and design shall be fitted on the front panels to indicate the service of each switch gear and equipment. Labels shall be of white plastic engraved with black figures or letters and fixed to the panel with brass screws. Labels shall also be provided to identify all items of equipment, circuits, cables and where applicable current rating of fuses and setting of relays.

8.2.11 Testing & Commissioning

Testing of the switchboard and certifying that it is safe before supply is energized, and that all the equipment complies with the requirements of this specification shall be done. Generally, such tests should include:

Demonstration that all equipment is installed and all wiring connected so that the board functions as required. Tests of accuracy of all measuring instruments.

Continuity, phasing out and insulating resistance testing. In general, the insulation resistance of sub-mains feeders and final circuits shall not be less than 50 mega-ohm when tested with a 500V megger. Protective equipment testing. Copies of test sheets showing the results of all tests carried out shall be submitted to the M&E Engineer.

Power Supply Company or local power authority tests on all equipment of the switchboard shall be performed prior to the connection of supply. Arrange for early testing of the switchboard immediately after it is completed. All fees in connection with the required tests shall be deemed to be included in the Tender Price.

8.3 Motors

All motors shall comply with BS5000 and shall be continuously rated. They shall have Class B insulation to BS2757. They shall be suitable for operation at ambient temperatures up to 45 deg. C. Motors shall be of the totally enclosed fan-cooled type.

Motors shall be sized for a non-overloading rating throughout the full range of operating points for the driven load. They should be capable of accelerating the driven load to full speed within the following times and starting currents:

Direct-on-line: Maximum starting current 6 times full load current and maximum starting time 5 seconds.

Star Delta and Other Forms of Starting: Maximum starting current 2 times full load current and maximum starting time 10 seconds.

All motors above 30kW in rating shall have a minimum efficiency greater than 92% and a power factor greater than 0.9 lagging under all load conditions. All motors above 3kW in rating shall have a minimum efficiency greater than 87% and a power factor greater than 0.85 lagging under all load conditions.

Motors of over 700W rating shall be 3 phase and motors up to 700W may be 1 phase.

Motors shall be capable of operating continuously at rated output at any frequency within 2Hz of nominal frequency and at any voltage within 10% of nominal voltage. Motors of rating 3kW and above shall be provided with six terminals for the windings. Motors smaller than 3kW may

have 3 terminals. Separate earthing terminals shall be fitted. Terminal boxes shall be of adequate size for the easy termination of supply cables. Terminal boxes shall be weatherproof.

Motors shall be vibration free. They shall be securely mounted onto the driven equipment or onto a common bedplate with the drive equipment. Properly selected vibration isolators shall be provided for the equipment to prevent transmission of vibration to the structure that supports them. Where variable speed drives are required to control motor speed, the subcontractor shall obtain written confirmation from the motor manufacturer that the motor is suitable for the duty intended. No additional cost will be entertained due to the tenderers failure to comply with this requirement. Motors shall be fitted with bearings with a design life of 100,000 hours. The tenderer shall submit confirmation of this with his tender.

8.4 Motor Starters

Unless otherwise stated starters for all equipment shall be mounted in the control board which controls that equipment. Starters for equipment for which the starter circuits are not shown in the Drawings shall be supplied complete with starters which are standard components of the equipment manufacturer.

Starters shall be rated for 60 start/stop per hour or to the intended duty for the motor/equipment supplied whichever is greater.

The type of starter shall be as follows except where variable speed drives are required:

Methods of starting motors shall be as follows:

Less than 3.0kW : Direct-on-line

3.0kW to 30kW : Star Delta

Above 30kW : Closed Transition Star Delta or Auto Transformer with minimum 3 steps

Resistors, inductors and auto transformers used in the closed transition star-delta starters and auto-transformer starter respectively shall be adequately rated to sustain the motor starting current for a minimum of 2 times the starting time and shall be protected against over-heating by means of a suitable sensor and cut off device. Where resistors are used it shall under no circumstances that the surface temperature of the resistor exceeds 50°C. All wiring connections to the resistors shall only be made in fire-resistant cables.

The auto-transformers starter shall be provided with sufficient number of steps at appropriate tapping such that it will provide a smooth start-up of the motor with starting current not exceeding 2 times the motor full load current at all times and a maximum starting time of not more than 10 seconds. In any case, the minimum number of steps shall be 3.

8.5 Variable Speed Drives

Variable speed drives shall be of high efficiency, low maintenance, ac adjustable frequency type employing the principle of Pulse Width Modulation (PWM) design. Direct current drives, eddy current belt drives, hydraulic drives and any other drives shall not be acceptable.

The variable speed drive shall meet the following minimum specifications as listed below:

- Input Rated Voltage Selectable: (415V, 3 Phase)
- Input Voltage Tolerance: +10% to -15% of Rated Voltage
- Input Frequency: 50 Hz
- Output Frequency Selectable (1-50 to 100 Hz)
- Frequency Stability: 175 parts per million/°C
- Acceleration/Deceleration: Continuously adjustable from 0.75 to 150 sec.
- Speed Input Signals: Can be any of the following;
 - 0 to 10V dc
 - 1 to 5V dc
 - 4 to 20mA dc

and shall be able to accept any form of differential or earth referenced speed signal from a standard transducer.

8.6 Fault Protective Circuits

The drive shall trip without any damage to its components when any of the faults described below happens. Each fault shall be identified by its own distinct LED indication. The drive shall be able to re-start after system reset.

- Earth Fault: When a phase to earth short-circuits appear on any or all phases.
- Short Circuit Fault: When a phase to phase short-circuits appear on any or all phases.
- Overcurrent Fault: When the output or regenerative current exceeds the maximum current rating of the drive.
- Under voltage Fault: When the input voltage falls below -15% of the rated input voltage or if there is a loss of one or more phases.
- Overvoltage Fault: When the input voltage exceeds +10% of the rated input voltage or if the regenerative voltage exceeds the internal DC bus voltage of 720 V dc.
- Over Temperature Fault: When the temperature of the internal heat sink rises above 80°C.

In addition to the above protective circuits, the drive shall also be provided with the following protections.

Line Transients

Insensitive to incoming power phase sequence

Current Limiting: 55 - 110% adjustable for maximum output current

- Remote Trip: An external motor overload device or a smoke detector may be connected to trip the drive when the contact of the overload device/smoke detector opens. A Remote Trip LED shall be lit.
- Stalling Prevention: The drive shall be designed with Acceleration and Deceleration Limit Circuit to avoid nuisance tripping when:
 - The starting current drawn is too high or the acceleration time set is too fast.
 - The regenerative voltage is too high or the deceleration time set is too fast.
- Start Boost: Switch adjustable from Low, Normal, Medium or High to provide different Volt/Hertz profiles (motor starting torque) at low speeds to suit different applications. A 0 to 100% Boost potentiometer shall be provided to give fine adjustment for each Boost Selection.
- Flux Compensation: Shall provide energy savings by automatically reducing the motor flux whenever the motor is not fully loaded, especially when the motor has been "oversized" for the load it is required to drive. Motor heating is also reduced. Very suitable for variable load applications like VAV system.
- Slip Compensation: Automatically adjusts output frequency and voltage as motor speed changes due to load variation. Provides improved speed regulation with large changes in motor load.
- Ambient Temperature Range Operating = 0 to 50°C.

The variable speed drive shall be the panel mount type and provided with the following features:

LED status indication showing the operational condition of the drive like:

- Power "ON"
- Zero speed
- Enabled
- Forward or Reverse mode
- Faults, e.g. Earth Fault, Overcurrent, Over Regenerative Current Under Voltage, Over Voltage, Over Temperature, Remote Trip
- Forward and Reverse Selector
- Run and Stop Switch

- Auto and manual speed selector
- Remote and local mode selector
- Digital speed meter able to be calibrated to read 0 - 100% speed

The variable speed drive shall have the capability, if required, to connect a load meter (digital or analog) to read the loading of the drive.

The variable speed drive shall be able to automatically restart itself after a fault has caused it to shut down. A minimum of five consecutive restart attempts shall be provided. If the fault persists after the fifth attempt, the drive shall shut down and cause the FAULT relay to energize. A manual reset is necessary after the removal of the fault.

The variable speed drive shall be complete with anti-harmonics filters as an integral unit to prevent dc current and harmonics current / voltage generated by the drive set from being injected back into the mains supply.

The limit of the harmonic distortions caused by the variable speed drive to the supply line shall not exceed the following at all times.

Harmonic Voltage Distortion

	Max. Allowable Individual Harmonic Voltage Distortion Up to the 19th Harmonic
Odd Harmonics	2%
Even Harmonics	1%

The allowable total harmonic voltage distortion shall not be more than 3%.

Harmonic Current Distortion

	Max. Allowable Individual Harmonic Current Distortion Up to the 19th Harmonic
Odd Harmonics	6%
Even Harmonics	4%

The allowable total harmonic current distortion shall not be more than 10%.

The filter shall be capable of withstanding 150% of the variable speed drive rated input current.

The Subcontractor shall verify that the limits of the harmonics distortions to the supply line are not exceeded on site in the presence of the M&E Engineer using an approval type of spectrum analyzer.

8.7 Control Descriptions

8.7.1 Booster Pumps

A selector switch shall be provided to select which booster pump is the duty pump. The duty pump shall start and stop in response to the pressure switch setting in the pressure tank. Upon failure to start by the duty pump, the standby pump shall start automatically.

Provide auto/off switch and run/fault indicator lights for each pump.

The pump operation shall be controlled by means of 2 pressure switches. Activation of pressure switch no. 1 shall activate pump no. 1, while activation of pressure switch no. 2 shall activate pump no. 2 deactivation of pressure switch no. 1 should cut out both the duty and standby pump. A time delay switch shall be provided to prevent the starting surge from cutting out the pump. The time delay shall be adjustable from 10 to 60 seconds. In the event of overload tripping of the duty pump the standby pump shall be brought into operation automatically

8.7.2 Submersible Pumps

The following controls shall be provided in the pump control panel located adjacent to the pumps:

- Auto/off/manual selector switch
- On "Auto" mode, pump shall start when High-Level electrode is activated and stop when the Low-Level electrode is activated
- On "Manual", pump control by start and stop push buttons
- High Level alarm shall be provided
- Separate level electrodes and indicator lights for the following:
 - Collection pit Low water level alarm
 - Collection pit High water level alarm
 - Pump run
 - Pump fault

8.7.3 Remote Mimic Panel (Optional)

The following indications should be shown on a remote mimic panel in the CCTV Communication & Control Room or the Maintenance Office:

- Fire sump water low level

- Booster pumps run and fault
- Fire pump run and fault
- Submersible pumps run and fault
- Wastewater collection pits high water level

Any of the fault signals shall sound an audible buzzer at this panel. Provide mute button to silence the alarm, but this shall not prevent the alarm from resounding if an alarm signal from another sensor is received.

8.7.4 Building Management System Interfaces (Optional)

The Sub-contractor shall provide but not limited to the following provisions in order to interface the Plumbing & Sanitary system with the building management System (BMS) as required by the Consultant. The BMS will have the following monitoring and control functions over the Plumbing & Sanitary Services installation as follows.

- Pumps
 - ON/OFF status indication
 - Switch mode status (Local/Remote)
 - Trip Alarm
 - Programmed start-stop command
- Tanks
 - High Level Alarm
 - Low Level Alarm
- Hydro-pneumatic Tanks
 - Water Pressure
- Sewer/Waste water Pits
 - High Level Alarm

Plumbing & Sanitary contractor shall liaise with the Main contractor & BMS contractor until the interface work is successful.

9. Painting & Labelling

9.1 Painting

Provide all paint, painting equipment etc. required for the painting of services. All plant and equipment, including motors, pumps, hangers, brackets and supports etc., shall be painted. All metallic surfaces shall be wire-brushed and cleaned from rust, scale, dirt and grease and shall then be painted one coat approved priming paint, not less than two approved undercoats and approved high gloss finishing coat.

The primer shall be red lead paint, the remainder oil paint.

All paints to be heat resisting. Color for painting to be selected by the Architect/M&E Engineer and different colors will be selected for different items and locations. The type of paint to be used shall be approved by the Employer's Representative before use.

9.2 Labeling and Identification

All plant and equipment provided under this Contract are to be labeled in English as to duty or services. All such labeling corresponds to schedules, diagrams etc. to be provided as part of the Record Drawings. Labels generally to be of 'Perspex' reverse engraved with red lettering, or as otherwise required by the Architect/M&E Engineer.

The following refers to specific items requiring labeling.

- All valves, motor starters, distribution boards, control panels, isolators and pumps etc.
- Control Panels, starters, etc. are to be labeled to indicate the circuit number, phase and item controlled.

Provide color banding of pipework as advised by the Architect/M&E Engineer and shall comply to BS 1710 or ASME A13.1 standards.

Recommended Manufacturers and Brands

- Water Pumps

Grundfoss

KSB

MasDaf

Wilo

Lowara

OR EQUIVALENT

- Wastewater submersible pumps

Grundfoss

Tsurumi

Evergush

Wilo

Masdaf

OR EQUIVALENT

- PPR Pipes & Fittings

Lesso

Aquatherm

Wavin

OR EQUIVALENT

- uPVC Pipes & Fittings

Slon

National

Lesso

OR EQUIVALENT

- HDPE Pipes & Fittings

Wavin

Lesso

Aquatherm

OR EQUIVALENT

- Valves & Accessories

Pegler

Kitz

Ayvaz

VIR

ValveIT

OR EQUIVALENT

- Pipe Brackets/Supports

Diamond

Tembo Sevenstar

OR EQUIVALENT

- Water Meters

B Meters

Baylan

OR EQUIVALENT

- Pressure Gauges

Jako

Winters

OR EQUIVALENT

- Hot Water Geysers

Ariston

Rheem

OR EQUIVALENT

- Sanitary Fittings

American Standard

TOTO

Duravit

Vitra

OR EQUIVALENT

- Tap Fittings

Grohe

Hansgrohe

Vado

OR EQUIVALENT

2. TECHNICAL SPECIFICATIONS OF MVAC SYSTEM

PRELIMINARIES FOR MECHANICAL SERVICES

2. GENERAL DESCRIPTION AND EXTENT OF WORK

2.1 Scope of Work

The scope of work under this specification covers manufacture/procurement, assembly, shop inspection & testing, shop painting, transportation of materials to site, storing, unloading and transportation from store to site and handling at site, erection, testing, commissioning and performance guarantee tests of equipment and accessories of all mechanical Services of the Project.

The scope of work by the Contractor shall include but shall not be limited to the following:

- To select, manufacture and supply the complete of all mechanical Services and associated equipment specified under this technical specification.
- To supply at the site required materials to execute incidental works at the site associated with all mechanical Services System plant/ system specified under this technical specification, providing first charge of consumables as required. The quantity and specification of such consumables shall be indicated during the tender stage.
- Supply of commissioning spares as may be required during erection, start-up and initial operation of all the units/systems till successful completion of commissioning. The price for the commissioning spares shall be deemed to be included in the contract price for the offered systems.
- Supply of recommended spares for two years of normal operation of the total mechanical Services with item-wise price breakup. The price for the two-year spares shall be deemed to be included in the contract price for the offered systems.
- Supply of special tools & tackles required for maintenance of all mechanical services. Preparation and submission of necessary load calculations, general arrangement drawings, design drawings, fabrication & erection drawings, as-built drawings, drawings of fast-wearing parts etc. Approval shall be taken on the load calculation, system layout drawings and equipment general arrangement drawings before the start of manufacturing.

- Erection of all the equipment and completion of total mechanical services system as per approved drawing and instructions of site engineer of customer / Owner/ Consultant.
- Minor civil work like breaking of wall /floor /roof to make duct/pipe/cable passage and adjustment to civil foundations as required for erection and finishing and making good of the same after erection work including painting thereof. Fixing of anchor fastener on wall and ceiling for support is included.
- Any other item /nature of work that specifically does not appear in the technical specification but is directly associated with the efficient working/completion of the system covered in the specifications.
- Submission of operation, maintenance and service manuals.
- Inspection and testing by Owner/Client's representative at works and site.
- Performance testing of various equipment associated with all mechanical Services at the manufacturer's works and also performance testing of all mechanical Services Systems at the site.
- All necessary skilled/unskilled personnel, cranes, hoists, tools and tackles, instruments and accessories shall be arranged free of cost by the Contractor for assembly, erection, performance testing and commissioning of the systems.
- Tenderer must note that completeness of the System for safe, smooth, trouble-free operation and compliance with Local/International regulation is the sole responsibility of the Contractor i.e., the successful Tenderer. With this objective in mind, the Tenderer should include all the items essential for the efficient operation of the systems and other items which are required to complete the erection and foolproof commissioning of systems in respects. Whether the items are mentioned in the specification or not, all such items are treated/ considered to be included in the specifications.
- When any services pass the fire-rated compartments/walls or any barriers all sleeves or openings are to be properly sealed with fire-rated sealants.

The contractor i.e., the successful tenderer shall be solely responsible for providing the above items at the site without any extra cost implication to the Client.

2.2 General Instructions to Tenderer

The technical specification inclusive of instructions/special instructions to the Tenderer shall be read along with General Conditions of the Contract (GCC) and instructions to

the Tenderer, for the supply and erection of plant, machinery, and equipment.

All items of equipment in this specification shall be complete in all respects including mechanical and electrical equipment as specified including fasteners, bolts and nuts, gaskets, base frames, stiffeners, supports etc. and any item not covered in this specification but essential for superior design, operation and guaranteed performance of the system shall be included by the Tenderer.

The equipment shall be designed, manufactured and tested by the relevant standards prescribed by the Sri Lankan Standard Institution wherever possible. In cases where suitable Sri Lankan Standards are not available, the equipment shall conform to Good Manufacturing Practices followed in the industry or recommended universal standards.

The equipment offered shall be suitable for continuous, smooth, efficient and trouble-free services in the climate prevailing at the site, continuous duty condition.

The Contractor shall not off-load the contract or part thereof to any sub-contractor without written permission of the Purchaser. In the event of subletting the contract or any part thereof is permitted by the Purchaser, the fact that such permission has been accorded shall not establish any contractual relationship between the approved sub-contractor and the Purchaser and nor shall release/ free the Contractor from the obligations under the contract. Facilities shall be provided by the Contractor to enable the Purchaser's authorized inspector to inspect the equipment and their auxiliaries at all stages of manufacture to satisfy themselves as to the use of proper material and workmanship and apart from this the equipment shall be tested or suitable test facility shall be provided by the Contractor to enable checking of operational parameters.

At the time of inspection, the Contractor shall furnish an internal routine inspection certificate, material certificates, approved drawings, etc. to the inspector. Inspection shall be regarded as a check only and shall in no way relieve the Contractor of his responsibilities to provide systems & equipment functions as designed.

The Contractor shall take full responsibility for the guaranteed operation and achieving rated output and performance of the systems offered as per the relevant clause of specifications.

The Tenderer shall information required for the smooth functioning of the systems including operation, day-to-day maintenance, preventive maintenance, capital repairs, schedules and programs and any other information required by the Purchaser for trouble-free operation of the systems along with the supplies.

The scope of work for the Tenderer shall not include the provision of room and foundation for the systems. However, the necessary load data shall be furnished along with the offer by the Tenderer to complete the civil work at the site as per the schedule of completion of respective buildings.

The Contractor shall ensure that all rotating elements viz impellers of fans and crank-shaft, piston assemblies shall be statically and dynamically balanced as per the relevant International / ISO standard.

The Contractor shall ensure that the speed of operation of all the mechanical and electrical equipment including technological auxiliaries and service equipment shall be kept low enough to reduce noise, vibrations and wear. When design parameters require higher speeds of operation of certain equipment, more than one stage shall be chosen over preference to choosing higher speeds.

The Contractor shall adhere to the schedule for supply, erection, testing commissioning etc. The Contractor shall ensure that each piece of equipment is provided with a nameplate engraved in the English language with the details like Supplier's address, operation and design parameters, weight, precautions etc.

The Contractor shall ensure that the systems are designed considering the fire safety norms and adequate fire safety measures in the form of hardware interlock provided accordingly.

This section applies to all sections of Mechanical Services except as specified otherwise in the individual sections.

The works to be done under this section of the specifications consist of the fabrication, complete in all details, of the Mechanical Services, at the subject premises, and all work and materials incidental to the proper completion of the installation, except those portions of the work, which are expressly stated to be done by others. All works shall be under the governing Codes and Regulations and with the Specifications, except where it conflicts with such Codes, etc., the former shall then govern. The requirements concerning materials and appliances necessary for the complete installation of the work are specified herein and indicated on the drawings. These specifications are intended to provide a broad outline of the required equipment but are not intended to include all details of design and construction.

Complete Mechanical Services shall be furnished and installed as shown on drawings and specified under this section. Coordinate timing of installation with work of other trades.

The systems provided shall be complete and operable and shall include required accessories, fastening, and supports. One coat of primer shall be provided for all fastenings and supports.

The contractor shall take necessary protection measures in order to avoid any damage to the already installed item, including pipe works and cabling works, while doing future

construction works. If any damage happens the contractor must reinstate them by his own cost.

2.3 Minimum Requirement for LEED Certifications

- Energy efficiency ratio/coefficient of performance of the all-air conditioning units shall comply with ASHRAE 90.1 Energy Standards for Buildings.

2.4 Standard Codes and Regulations

All works performed, and equipment and materials supplied and installed under the contract shall comply in every respect with the rules and regulations of:

- Relevant ICTAD Specification
- Relevant ASHRAE Standards
- Local Fire Regulation
- Current Edition of the relevant British Standard Codes of Practice.
- The relevant British Standard Specifications (BS) or approved equivalent.
- All other authorities have jurisdiction over the installation.

2.5 Standards Compliance

Materials and equipment specified to conform to referenced standards and codes require proof of such conformance. Labels or listings indicating such compliance are acceptance evidence. Instead of labels or listings, provide a certificate from an independent testing organization acceptance to the Engineer.

For materials and equipment whose compliance with organization standards or specifications is not regulated by listing or label, provide the manufacturer's certificate of compliance.

Certificates of compliance shall identify the manufacturer, product, referenced standards and manufacturer's certification that the product conforms to all requirements of the project specification and listed reference standards.

2.6 Authorities Inspection, Testing and Approval

The Contractor shall file all plans, application permits, etc., and shall complete all tests, forms, etc., arrange all inspections etc. as required by all rule's regulations, etc., of all

the Government Authorities having jurisdiction and such shall be completed by personnel of proper caliber, in particular, Professional Engineers, where so required.

The works shall not be covered up before the inspection and the approval of the authorities. The Contractor shall give due notice as required by the Authorities whenever such works are ready or about to be ready for inspection and testing. They shall afford full opportunity and co-operation of the authorities to carry out the inspection and testing and shall deemed to have allowed in the tender sum for such inspection, any fees payable any necessary phasing and temporary suspension of works and other costs resulting thereby.

Should any works be covered without prior inspection and approval, the Contractor shall uncover any parts or part of the work or make openings in or through the same, as the Authorities may direct for inspection. The Contractor shall at its own expense reinstate and make good any such part or parts to the satisfaction of the authorities and Superintending Officer.

The Contractor shall furnish all required Certificates of Approval.

2.7 Schedule of Technical Data and Manufacturer's Technical Pamphlets.

The manufacturer's Technical Pamphlets giving full technical data for all equipment to be offered by the Tenderer shall be submitted together with the Tender. The Schedule of Technical Data shall be dully filled. Equipment to be offered by the Tenderer shall bear both the Manufacturer's Name and List Number.

Phrases like "As Specified", "Equivalent" "Submit at a later date", and "Local Made" will not be acceptable in the Schedule of Technical Data.

Where there is a discrepancy between the Schedule of Technical Data attached to the Tender Documents and the Specifications mentioned on the Manufacturer's Technical Pamphlets, the Schedule of Technical Data should prevail.

Tenderers must fill in their tender strictly in compliance with the Engineer's base specification in regards to nominated makes of equipment/material. Any error in specifications must be clarified with the Engineer before submission of tenders, who will issue addenda thereof.

The original form of Schedule of Technical Data must be filled per the Engineer's base specification or amendments thereof, failing which the client reserves the right to ask the Tenderer to comply with the Engineer's base specification at tendered price or else the client reserves the right to forfeit the Tenderer's Tender Deposit and Tender Bond.

Tenderers are fully encouraged, however, to propose alternative specifications which can

achieve genuine economy in cost or technical benefits, but these same alternative and their cost implication thereof must be filled separately in a separate covering letter with a Schedule of Technical Data and not the original Tender Schedule.

2.8 Equipment and Material Approvals and Samples Review:

Within 14 days after the award of any contract, the Contractor shall submit for approval a list of manufacturers of equipment and material proposed for the work. The Contractor's intent to use the exact makes stated in their tender does not relieve them of the responsibility of submitting such a list. All equipment and materials shall be new and unused.

Wherever the words "equal", "approved equal", or "as approved" appear in the specification, this shall mean approved in writing by the Consulting Engineer.

Each item of equipment shall be a standard catalogue product of an established, reputable, approved manufacturer. All similar equipment shall be of the same manufacturer, type, class and finish unless otherwise specified.

Where manufacturer's catalogue numbers or types are specified or shown on the drawings, they are generally intended to be used as a guide and are not intended to take precedence over the basic duty and performance specified or shown. In all cases, verify the duty with the particular characteristics of the equipment offered for approval.

Where no alternative materials are noted in the specification or on the drawings and where the words "equal", "approved equal", or "as approved" etc., do not appear, the exact make specified must be supplied and installed.

Orders must be placed within thirty (30) days of tender award. Major equipment orders shall be forwarded to the Consulting Engineer for approval before purchase.

Samples: Where approval of products is specified submit samples or other evidence of suitability for review by the Engineer. Resubmit samples as necessary until an acceptable standard is reached. Do not confirm orders, commence manufacture or use products until approval of samples has been obtained.

Materials Application: Materials submitted for review shall be forwarded using a standard application form format to be agreed with the Engineer. Enter the date by which review information is required. Allow a reasonable time for review and indicate urgency where necessary.

Review Categories: Shop drawings, Materials Samples, Mockups and similar submittals will be reviewed and classified in one of the following categories:

- | | | |
|-----|--|----------------------------|
| • A | Approved without comment | - No resubmission required |
| • B | Approved when comments are fully complied with | - No resubmission required |
| • C | Approved with comment | - To be resubmitted |
| • D | Disapproved | - To be resubmitted |

Mock-ups: Provide mock-ups as required by the specifications. Mock-ups will be subject to review and are to be adjusted until an acceptable standard is achieved. These are then to be protected and remain in place to form a minimum standard for comparison of subsequent work. Mock-ups may form part of the final construction as may be agreed upon and directed by the Engineer.

2.9 Equipment and Material Deviations

The dimensions and ratings of equipment specified herein or indicated on the drawings are intended to establish the outlines and characteristics of equipment furnished by the particular manufacturer or manufacturers specified.

Where the Contractor intends to use an item of equipment or material other than that specified or shown on the drawings or in the Schedules, the Consulting Engineer's approval therefore must be obtained in writing.

Should any tenderer include in his offer equipment or material other than that shown in the drawings and schedules, such equipment or material must conform fully to the requirements for these items as shown in the drawings and schedules. Acceptance of any tender which includes equipment and material which differ in any respect to that equipment and material shown on the drawings and Schedules, in no way relieves the Contractor from complying with the specification, drawing and Schedules.

Where such approved equipment deviations require a different quantity and arrangement of piping, wiring conduit and equipment from that specified or shown on the drawings, the Contractor shall furnish and install any such additional piping, structural supports, electrical materials, insulation, controllers, motors, starters and equipment required by the system without additional charge.

2.10 Submittal

The following items shall be required to be submitted to the Engineer for review and certification.

a) System Design Calculation

Assumptions and basis of selection for the system components. Design calculations as required by the Engineer for review.

b) Design and Shop Drawings

Complete system design layout and description of components for all piping schedules. Schedule and description of pipe fittings and valves.

c) Test certificates for the system.

d) Current active welder's certificate and welding procedures for welding works to be done together with tender document.

e) Schedule of Contract Work, Schematic and Interconnection Diagrams, Monthly Progress Report and Operation and Maintenance Manual

2.11 Intent of Drawings and Specifications

It is the intent of the Specification and drawings relevant to this Contract to call for finished work, tested and commissioned. Any apparatus, appliance or material not shown on the drawings but which is mentioned in the specification or vice versa, or any incidental appliance or materials, services which may be necessary to make the work complete and perfect in all respects and ready for operation, even if not particularly specified, shall be furnished, delivered and installed without any additional costs.

The plan as drawn is based upon architectural plan and detail and shows conditions as accurately as it is possible to indicate them in scale. The plans are diagrammatical and do not necessarily show all accessories, fixings etc., necessary to fit the building conditions.

The locations of outlets, apparatus and equipment shown on the plans are approximate. The Contractor shall be responsible for the proper location of all devices to make them fit with architectural details and instructions from the Engineer's representative at the site.

2.12 Shop Drawings, Working Drawings and Details

After receiving approval from the equipment manufacturers submit for approval, without delay, and before purchase or fabrication, not less than six (4) copies of

detailed, dimensioned shop drawings or cuts of equipment showing general construction, size, arrangement, levels and setting out details, fixing details, operating clearances, related builders work information and requirements, performance characteristics and capacity of all specialties, together with sufficient engineering data to indicate substantial compliance with the respective specifications

Positions of all control equipment, including related components, shall be shown on shop drawings.

Each item shall be identified by name and number as shown on the equipment schedules, control drawings and specifications.

Working drawings of the complete installation, prepared by the Contractor shall be submitted in triplicate for examination and comment. Each drawing will be examined and approved corrected or disapproved by the M&E Engineers and returned to the Contractor, who shall then print the necessary copies of each approved submission for distribution. Disapproved drawings shall be corrected and resubmitted.

Drawings shall be of 1:100 scale minimum except in critical areas where 1:50 or larger scale as appropriate shall be used.

Inspection of shop and working drawings shall not be considered as a guarantee of measurements of building conditions. Where drawings are inspected, such inspection does not in any way relieve the Contractor from his responsibility nor from the necessity of furnishing material or performing work required by the contract drawings and specification, which shall, in the event of a dispute, take precedence over shop drawings.

The submission of shop and working drawings (in either the original submissions or resubmitted with corrections) constitutes evidence that the Contractor concerned has checked all information thereon and that they accept and are willing to perform the work as shown in a workmanlike manner and in accordance with the best standard practice. It also constitutes evidence that all control diagrams, all electrical diagrams and all submissions of any kind are fully understood by the Contractor and that in their opinion the equipment will perform as specified. No claim for extra shall be based on work shown on shop and working drawings unless such claim is so noted on the Contractor's transmittal letter accompanying the drawings.

A responsible person of the Contractor's staff shall sign all drawings submitted, including those by suppliers.

Submit for approval within fourteen (14) days of the contract being awarded two (2) copies of a schedule of shop drawings showing the following:

- Drawing Number
- Title
- Planned Date of Submission

Dates of submission and approval shall be coordinated with the Building Programmed. Shop drawings shall be submitted for inspection to the M&E Engineer, a minimum of 21 days before the required return date.

Failure of the Contractor to include all shop drawings on this schedule shall not relieve them of their responsibility to submit all required shop drawings on time to permit correct processing as specified herein.

The Subcontractor is responsible for ensuring that shop drawings are kept up to date by incorporating modifications arising from instructions. Reissue updated shop drawings as may be required by the Engineer.

2.13 Record Drawings, As-Built Drawings, and Operation and Maintenance Manuals

Record Drawings: During the works, the subcontractor shall maintain fully detailed records of all changes from the tender drawings to facilitate easy and accurate preparation of the record drawings and to ensure that these drawings are in all respects a true record of the installation.

Content: The drawings shall show the complete installation, including the size and runs of all ducts and pipework. The scales shall be such that details, particularly of the plant, can be clearly shown. The drawings shall show the names of the manufacturer, model and type numbers and all the details of duty and rating of all items of the plant, including thermostatic control equipment. The drawings shall include the geographical location and identification number of each circuit control valve by the labelling and circuit control diagram.

Diagrams: A print of each of the composite record circuit and layout diagrams shall be fixed securely to the inside of the hinged front of the main electrical control panels as appropriate, or in such other alternative positions as may be agreed by the Engineer and shall be protected by a nonflammable transparent material. Where inadequate space exists, the prints shall be suitably reduced in size.

Operations and Maintenance Manuals: The Contractor shall also provide Operations and Maintenance Manuals, Wiring diagrams, valve charts, test certificates and the like as required by these Specifications. Three copies of the Operations and Maintenance Manual shall be handed to the Engineer before Practical Completion. 2 copies of the O & M manual In CD format shall also be submitted. The files in the CD shall be in PDF or text format.

Manual Format: The format of the manual shall be A4 size white paper for typed pages with neatly typewritten text, and manufacturer's printed data. Drawings shall be sized so that they may be folded to the size of the text pages. Each volume title of the manual shall be identified with the typed or printed title, 'Operations and Maintenance Manual', the title of the project and the identity of the general subject matter covered in the manual. The text and drawings shall be placed in commercial three-ring binders with durable and cleanable plastic covers. When multiple binders are used, the instructions shall be correlated into related consistent groupings. Each manual volume shall contain a neatly typewritten table of contents arranged in a systematic order giving the subcontractor, the name of the responsible principal, address and telephone number, and a list of the name, address and telephone number of the subcontractor or installer. Only the manufacturer's printed data, which is pertinent, is to be included. Each sheet of manufacturer's instructions shall be annotated to identify the specific item or part installed and the instructions applicable to the installation. All inapplicable information shall be deleted.

Supplementary Data: Data shall be supplemented with drawings as necessary to illustrate parts of equipment and systems, control diagrams, flow diagrams and test procedures covered in the manual. The written text shall be organized into a consistent format under separate headings for different procedures and in a manner to provide a logical sequence of instructions for each procedure.

Organization: Organize the Operations and Maintenance Manual as follows: Volume 1 :

Part 1: Introduction

Part 2: System Description

Part 3: Operating

Procedures Part 4: Fault Finding

Part 5: Preventive

Maintenance Part 6:

Appendices:

List of Drawings

Equipment Data and Spare

Parts List of Manufacturers and Agents

Volume 2: Publications (catalogues, selection tables, etc.)

Contents :

The content of the manual shall include those items contained in the above schedule and each item shall cover the following points:

- Description of plant, equipment, parts and finishes
- Operating procedures, including step-by-step instructions for pre-start, starting up, normal operation and shutting down of the plant, equipment and components, safety

features

- Maintenance procedures, including routine operations, guide to troubleshooting and fault finding, procedures for assembly, repair and reassembly, and procedures for alignment, adjusting, checking and cleaning
- Servicing, lubrication and cleaning schedule, including list of lubricants required and filter replacement
- Manufacturer's printed operating and maintenance instructions
- Circuit directories of panel boards, dial servicing and instrument checking
- As installed colour-coded wiring diagrams.
- Details of each item of plant, including the name and address of the manufacturer and local agent, type and model, serial number, duty and rating.

Operations and Maintenance Instructions:

The Contractor shall demonstrate and explain the plant and the method of starting, running and stopping to the Architect or Employer's representatives. During the defects liability period, the Contractor shall allow for providing trained operators to attend, operate and maintain the plant as directed by the Architect. Demonstrate the purpose, function and operation of the installations including all items and procedures listed in the Operations and Maintenance Manual. Over this period the operators shall also instruct the Employer's staff in the correct maintenance and operation of all plant and equipment. The Contractor shall also assist the Employer in formulating any maintenance contracts with suppliers of equipment and Contractors that the Client may require. The Contractor shall provide five sets of operations and maintenance instructions (hard copies) and two (2) soft copies of the O & M manual In CD format. The files in the CD shall be in PDF or text format.

Record Drawings (i.e., updated shop drawings):

Unless otherwise indicated, the Contractor shall provide before the Practical Completion the following drawings:

- Four sets of installation working drawings.
- Four sets of detailed plant room drawings.
- Four sets of purpose-made diagrams detailing separately all the composite electrical circuit and wiring layouts.
- Four sets of builder's work drawings.
- one set of reproducible as fitted drawings, process negatives and computer discs for use with AutoCAD upon completion of the work

Completion:

Adjust copies of all Shop Drawings to record the final installation. Submit five (5) complete finalized sets before Practical Completion. Supply copies of all associated supplementary manufacturers or other data necessary to form a complete record of work

done.

Additional Data:

Provide details of any errors, variations, omissions or additional information which is not instructed, directed or indicated on the sub-contract drawings, but which becomes apparent from construction. Information is to enable record drawings to form an accurate record of final construction. Details are to be submitted as the work progresses and shall be completed by the Practical Completion.

Manufacturer's Input:

Retain copies of maintenance instructions and documents delivered with components and equipment or obtain from the manufacturer as necessary and submit before Practical Completion.

Spare Parts:

On completion of the testing and commissioning of the mechanical services installation, spare parts required by the specification shall be supplied and submitted.

List:

At the time of handover provide a comprehensive list of all manufacturers suppliers and local agents for all items used in the construction of the works. Include the following data:

- Product/ service
- Specification/ instruction reference
- Company name
- Address
- Telephone and fax numbers
- Contact name, title and position

Upon completion of the job, the Sub-Contractor shall furnish to the Owner, their original tracings or reproducible transparencies of all electrical works, shop drawings and equipment layouts. They shall note on the as-built drawings, furnished by them, the corresponding number of the applicable

shop drawings. Where shop drawings are not available, the Contractor shall neatly indicate the changes on the as-built drawings.

2.14 Handing Over Documents

The final handing over documents to be submitted by the Contractor on completion of the installation shall comprise the following:

- a) Operation and Maintenance Manuals (3 copies)
- b) Commissioning Sheets (3 copies)
- c) Test Reports (3 copies)
- d) As-Built Drawings (3 copies)

These documents, in the required number of copies specified, should be supplied to the Engineer within 30 days of the issue of the taking-over certificate. All documents submitted shall be of hardbound cover.

2.15 Technical Literature of Equipment

Technical literature of all equipment proposed to be used in the system inclusive of dimensional drawings, capacity tables, test reports and other relevant information shall be supplied in **quadruplicate** for the Engineer to determine the adequacy and suitability of the equipment for the proposed air-conditioning system. All technical submissions shall be in English.

Three number of documents shall consist of original manufacturer's catalogues or coloured printouts of manufacturer's catalogues.

The contractor shall emphasize/ highlight the model numbers, serial numbers and major technical details of the proposed equipment for the reference of the Engineer.

2.16 Monthly Progress Report

The contractor shall submit a detailed report to the Engineer by presenting the progress of work at the site for each month. The report shall include photographs of site premises to validate the facts mentioned in the report.

The actual completion time for every task shall be analyzed with the scheduled time target stipulated in the Schedule of Contract Work. The contractor shall justify the reasons for lapsed tasks and shall submit a proposal to expedite the same work to align with the scheduled time targets.

2.17 Quality Assurance

The Contractor shall operate and maintain a Quality Assurance programme to ensure that the Contract is completed in accordance with the approved programme and to the standard specified.

Work procedures shall be documented and shall be available to satisfy the Architect of the effectiveness of this programme in the following areas at contract execution.

- Design
- Procurement, manufacture and packaging
- Construction and erection

2.18 Manufacturer's Instructions

Where installation procedures are specified to be per the manufacturer's instructions, provide published copies prior to installation. Installation of materials and equipment will not be allowed until the instructions are received.

Failure to furnish the manufacturer's instructions can be a cause for rejection of the materials.

2.19 Progress Photographs

Progress Photographs: In addition to progress photographs required for monthly progress reports keep a portfolio of progress photographs on site which act as a record of the progress of key areas of the works and key events as directed by the Engineer.

2.20 Completion and protection:

Protection: Protect building finishes, fixtures and fittings and prevent damage to existing property. Move, cover and protect as necessary to enable the works to be executed and replaced in original positions upon completion.

Special Protection: Wherever work is especially vulnerable or is exposed to abnormal risks provide special protection to ensure that damage does not occur. Replace or repair any damaged components or finishes.

Waste Material: Remove rubbish, waste, debris and surplus material regularly and keep the site orderly and clean. Remove all rubbish, dirt and residues from voids and cavities in the construction before closing in. Dispose of waste material at an approved location and obtain all necessary permits.

Cleaning and touch-up: Remove all temporary markings, coverings and protective wrappings unless otherwise instructed. Clean finished work thoroughly and remove all surplus material. Cleaning materials and methods shall be as recommended by product manufacturers. Touch up minor faults in finishes or repaint badly marked areas back to suitable breaks or junctions

Lubrication: Adjust, ease and lubricate moving parts of new work as necessary to ensure easy and efficient operation.

Defects: Defects are to be reported to the Engineer without delay. Obtain directions before proceeding with work which may cover up or otherwise hinder access to defective construction or be rendered abortive by the carrying out of remedial work.

2.21 Practical Completion

Preparation: During the weeks leading up to Practical Completion, the Architect and engineering Consultants will monitor commissioning tests with the Contractor and his subcontractors. A programme of such tests is to be agreed upon well in advance to ensure a systematic and progressive approach towards building handover. The Contractor shall pay particular attention to the production of Record Drawings and Maintenance Manuals. Their production will be progressively reviewed so that they are finished by the Date for Completion.

Preparatory Inspection: Two weeks prior to the anticipated date of Practical Completion a formal inspection of the works will be undertaken jointly by the Architect, engineering Consultants and the Contractor. The Employer will be invited to send representatives to this inspection. Lists of defective and incomplete work are to be prepared together with the Architect and engineering Consultants, together with a checklist of outstanding documentation related to the documents required to be handed over by the subcontractor at Practical Completion. The Architect will consolidate these lists and forward them to the subcontractor for action. Action related to the lists will be monitored in the remaining period to Practical Completion.

Handover: As soon as the Architect is of the opinion that Practical Completion has been achieved, he will arrange a formal Handover Inspection with the Employer. Any remaining defects or pending documentation will be listed for immediate action by the subcontractor within seven days unless otherwise instructed by the Architect.

Defects Liability Period: Defects will be reviewed at joint site inspections with Consultants and Contractors. The Architect will coordinate input from all disciplines and prepare a Defects List that will be updated and reissued following inspections throughout the Defects Liability Period. Permission for access to accommodation for making good defects is to be obtained strictly in accordance with Employer, Contractor and user requirements. Defects are to be made promptly and expeditiously.

Training: The Contractor shall allow in his Contract price the service of competent personnel to instruct the Owner's maintenance staff in the operation and maintenance of the installation and equipment during the initial operation of the system, after the issue of the Certificate of Practical Completion or handing over of the Works to the Owner whichever is earlier.

2.22 Maintenance and Guarantee

All equipment supplied and installed shall be in good working order and shall be guaranteed for 12 months from the date of handing over the completed installation to the Owner. This guarantee shall include the equipment manufacturer's standard warranties and the Contractor's guarantee on all other materials supplied and installed by them.

The Contractor shall make good any defects to the components of the equipment that may arise from fair wear and tear during the guarantee period.

Any component of the installation which fails to achieve the guaranteed performance is to be replaced by the Contractor without delay and any charge.

During the above-mentioned guarantee period, the Contractor shall provide free regular monthly maintenance to all Mechanical Services and ensure that all systems are maintained in first-class running order. The maintenance shall include systematic examination, cleaning, adjustments, testing and lubrication and shall cover the replacement of parts due to fair wear and tear.

During this guarantee period, the Contractor shall also provide emergency breakdown maintenance.

The Contractor shall maintain a detailed record of all services, maintenance and repair work carried out. Such record shall be prepared in duplicate and should be in the form of a Maintenance/Repair sheet, with one copy to be retained by the Owner upon the execution of such services. Record of such service, maintenance or repair shall also be entered in the maintenance log book provided at the site.

2.23 Day works

Submittals: Day work sheets shall be submitted regularly not later than the end of the week following that in which Day works were done. The Contractor is to submit Day works sheets to the Architect's site office.

These will then be distributed to respective Consultant disciplines for review, checking, verification and approval. Submittals will not be accepted if Day works sheets are incorrectly filled out or submitted unsigned. Submittals will not be accepted which, in the opinion of the architect and/ or engineer, do not accurately reflect actual Day work done.

Formats: Day worksheets shall be in a standard format to be approved by the Architect. The format is to run every week. As a minimum form shall include the:

- Date
- AI reference
- Hours worked
- Cost column
- Labor type/ trade
- Name of person

- Work done by room number and/ or system
- Signature and date of subcontractor foreman

- Architect approval signature and date box.

Contractor Authorization: The Contractor shall provide the Architect with the names and position/responsibility of each person authorized to sign Day works sheets.

Consultants Authorization: The senior resident architect, senior resident engineer or designated counterparts are authorized to sign Day works sheets.

Distribution: All approved Day works sheets are to be returned to the Architect and thence to the Quantity Surveyor at regular intervals, at least monthly. Rejected Day works sheets will be returned to the Contractor not later than 14 working days after the date of receipt by the Architect.

3. GENERAL REQUIREMENTS

3.1 General

The works shall be executed in accordance with the conditions of the contract, specifications and design conceptual drawings.

The design conceptual services drawings shall be read in conjunction with the Architectural and Civil Structural drawings, before installation works.

3.2 Design Conditions

Unless otherwise indicated the various plant capacities shall be selected with the following tropical design conditions:

1. Outdoor Conditions

- a. Dry bulb temperature - 32°C - 35°C
- b. Reflective humidity - 75% - 90%
- c. Maximum Temperature in Direct Sun - 40°C

2. Indoor Design Conditions

- a. Air-conditioned spaces – 21±1°C DB and up to 55-70% RH (Cold Chain Facility Area & Vaccine Packing Area)
- b. Air-conditioned spaces – 24±2°C DB and up to 55-70% RH (Other Area)
- c. Non-air-conditioned spaces - 29°C DB/24.5°C WB and up to 80% RH

The subcontractor shall be responsible for the proper selection/installation of equipment to meet the specified conditions.

3.3 Tropicalization

All selected equipment, materials and their finishes shall be tropicalized to meet the humid tropical conditions under which the equipment will work and comply with the recommendations of BS CP 1014. **All equipment shall be suitable for areas of high pollution of saline air under the marine category.**

All iron or steel parts shall be galvanized or painted as listed in the specifications.

Indoor parts may alternatively have chromium or copper-nickel plating or other approved protective finish. Steel screw, where used, shall be chromium plated or, when plating is not possible shall be of stainless steel. All nuts, bolts, and washers, which are exposed to the weather or in contact with moisture, shall be stainless steel to BS 6105. All nuts and bolts shall be of uniform thread and conform to Isometric sizes.

Instrument screws shall be of brass or bronze.

Adhesive shall be specially selected to ensure the use of types, which are impervious to moisture, resistant to mould growth and not subject to the ravages of insects.

Fabrics, cork, paper and similar materials, which are not being impregnated, shall be treated with an approved fungicide or so treated to make it resistant to the ravages of insects.

Neoprene, rubber, rubberized synthetic compounds and similar materials shall not deteriorate due to climate conditions. The use of wood in equipment is to be avoided.

3.4 Method of Fixing

Unless otherwise approved, all fixing of hangers and brackets shall be done using an expansion anchor/raw plug. Wooden and plastic plugs will not be allowed.

Explosive charge fixing devices shall only be used when and where approved by the Local Authorities and the Architect. In this case, the manufacturer's recommended procedures for fixing should be strictly adhered to.

Fixing to structural steel shall employ proprietary clamps. The structural steel shall not be drilled or welded without approval.

All plants such as motors, pumps, fans etc. shall be secured with hold-down bolts, the subcontractor shall supply and arrange the hold-down bolts to be cast in concrete plinth or structure by the main contractor and shall also be responsible for its correct alignment and spacing.

3.5 Packing and Transport to Site

The subcontractor shall ensure that each item of equipment or instrument is properly packed and protected for transport and shipment from the place of manufacture to the site.

Open pipe ends shall be protected from external damage and ingress of dirt, moisture and insects during transit and while awaiting erection at the site.

Where practicable, all indoor items such as switchgear shall be enclosed with polythene sheeting sealed at the joints and the enclosure provided internally with approved desiccators.

Equipment found damaged, dented or deteriorated when delivered to the site will be rejected.

3.6 Comment by the Tenderer

Any comments by the Tenderer on the efficacy of the design, discrepancies, the adequacy of plant room space, the availability of plant, materials and labour and the time required for the completion of the work shall be made at the time of returning the tender.

3.7 Setting Out

The setting out and installation of all pipelines and associated works shall follow closely the approved drawings except where on-site variations are approved by the Architect.

The contractor will at all times be fully responsible for the correct positioning and installation of all works and equipment installed by him in accordance with the Specification and in consultation and cooperation with all other trades.

3.8 Core holes

Setting out dimensions shall not be scaled from the services drawing. Only site measurement- approved shop drawings and architectural and Interior design dimensioned drawings shall be used for setting out. The sub-contractor shall, before the pouring of concrete furnish for the approval of the Architect, produce drawings showing the details and locations of all core holes to be cast into beams, floor slabs, walls, etc. No core holes shall cut through any structural member without the approval of the Architect.

3.9 Specialized Equipment

The sub-contractor shall request the manufacturer/equipment supplier to formally acknowledge the equipment/system supplied by them is installed in a manner that receives their full recognition and acceptance.

3.10 Protection of Existing Structures

All existing water and other pipes, electric conduits, sewers, drains and other structures shall be carefully supported and protected from injury by the Contractor and in the case of injury, they shall be restored by him without additional compensation to the satisfaction of the Superintending Officer.

3.11 Dissimilar Metals

Dissimilar metals shall be separated from direct contact with each other. Supply necessary gaskets dielectric couplings and the like. Copper shall not be used upstream of galvanized materials. Fastenings shall be equivalent or exhibit better corrosion resistance than the materials jointed or held.

3.12 Radio Frequency Interference

All equipment supplied under this contract shall be equipped with radio frequency interference suppression in accordance with the BS Standard applicable to that equipment.

3.13 Fire Stopping

An approved type of fire-stopping system shall be used to seal all openings through walls and floors against the spread of fire and hot gases after the installation of cables, pipes and ducts as well as abandoned openings.

The fire-stopping system should be easily applied, intumescent and resistant to water, solvents, acids, humidity and other industrial influences. The applied thickness shall give a fire rating equivalent to that afforded by the partition or floor in which the opening is made.

Where necessary, a specialist shall be employed and paid by the contractor to carry out the fire- stopping works.

3.14 Proprietary Computer Software Licensing

All proprietary software supplied with any computer equipment shall be properly licensed. A licensed agreement between the Employer and the vendors of the proprietary software packages shall be included in this subcontract and all costs and royalties shall be paid by the subcontractor.

3.15 Protection and Surface Finishes

Protection against corrosion (due to high salinity environment), deterioration, absorption of moisture and the like shall be provided for all materials and equipment and shall be finished in approved colours and qualities of finishes.

Galvanizing shall be carried out in accordance with BS729, but shall achieve the following

thickness of zinc coating:

- All external steelwork / pipework / fixings shall be provided with 460g/sq. m zinc coatings.
- All internal steelwork required to be galvanized shall be provided with 335g/sq. m zinc coatings.
- All grey and malleable iron castings shall be provided with 610g/sq. m zinc coatings.

Damaged galvanizing shall be touched up with one coat of zinc-rich paint.

All materials exposed to view shall be cleaned, degreased and painted with a suitable primer, undercoat and two finish coats to a total dry film buildup of not less than 0.1mm. The finished coat colour shall be as directed by the Architect.

Concealed steel parts shall be cleaned, degreased, primed and painted with one undercoat, including steel pipe to be insulated.

Chromium plating if specified shall be to the requirements of BS 1224.

3.16 Painting

All surfaces to be painted shall be thoroughly cleaned degreased and painted as follows:

All Pipe brackets should be Hot dipped Galvanized & all external Pipe brackets should have a minimum 20 µmm film thickness.

3.16.1 Equipment

Manufacturer's equipment needs not to be painted other than touching up due to site damage, provided the paint system provided has been properly applied and results in one of the following:

- 35 microns for oven-baked enamel surfaces.
- 45 microns for sprayed and warm air-dried finishes.
- 80 microns for brush applied enamels

3.16.2 Galvanized Surfaces

Shall be cleaned with a suitable pre-paint treatment, immediately followed by one coat of galvanized iron primer, followed by one coat of undercoat in a contrasting colour, and one final coat to the specified colour.

For external galvanized surfaces and pipe, the subcontractor shall provide a paint system with suitable technical support to demonstrate that the oxidation rate of zinc will not be accelerated by the proposed painting system.

The total dry paint film build up shall be 80 microns. The final coat need not be applied

to externally insulated sheet metal ductwork.

Touching up to damaged areas shall be zinc rich powder-based paint to give equal protection to undamaged areas.

3.16.3 Mild Steel Surface

Pre-treatment shall be as per above, followed by one coat of anti-rust primer, 1 coat of metallic lead primer (or equal) in a contrasting colour and one finishing coat of super enamel for a total paint buildup of 80 microns.

3.16.4 Stainless Steel, Copper

Need not be painted, except for the identification of its use.

2.16.5 Concealed Work

Pipe-work and ductwork concealed in walls shall be thoroughly cleaned and primed; finishing coats need not be applied.

2.16.6 Areas with no Ceiling

For areas with no ceiling, the finishing coat shall be to the Architect's selected colour.

4. TECHNICAL SPECIFICATION FOR MVAC SYSTEM

4.1 Introduction

The scope of the project covers the Supply and Installation of Air Conditioning Systems (VRV/VRF Units) and mechanical ventilation systems.

This section consists of the general rules that apply to the design, manufacture, shop testing, delivery to site, installation, commissioning, and site testing, maintaining and handing over the material, equipment, plant and services required for the Air Conditioning System of the project.

The scope of the works under this contract would be limited to the Supply and Installation of Air Conditioning Systems - VRV/VRF Units and mechanical ventilation systems. The Civil Works and other Building services etc. are being executed under separate contracts.

The site is located at the Hulhumale, Maldives. Relevant civil works are tendered in parallel.

The site is developing as a facility providing premises for the cold rooms which are using for the vaccine packing purposes.

All equipment being supplied shall be suitable for operation under tropical conditions with ambient temperature up to 36°C and relative humidity up to 80-90% but not both simultaneously.

Refrigerant pipes and condensing water pipelines have been installed according to the given specifications. The refrigerant pipelines and condensing water pipelines are terminated near the indoor units and outdoor units. The air conditioning contractor shall carry out all necessary connecting works from terminated points to indoor & outdoor units. After doing the necessary connection the piping system shall be vacuumed & pressure tested before filling the pipelines with the refrigerant.

Three-phase electrical power supply to outdoor units will be terminated on a 4-pole isolator near the outdoor unit and the power supply to indoor units will be terminated on a 13A socket outlet near the indoor units. The air conditioning contractor shall carry out all wiring from these isolators and socket outlets.

The bidder shall fulfil the following requirements before submitting the tender package.

- The bidder shall have at least **five (5)** years of experience in Supplying, Installing, Testing, Commissioning and Maintenance of similar types of Air Conditioning systems and have qualified technical staff trained at VRV/VRF manufacturing facility for installation, operation, maintenance & troubleshooting of modern VRV/VRF Systems.
- The manufacturer of the equipment shall have at least **fifteen (15)** years' experience in the Design and Manufacture of similar types of Air conditioners and the offered equipment shall have at least **five (5)** years of proven service record in Maldives. The country of origin of the VRV/VRF must be Japanese, American, UK or European.

Tenderer must note that the completeness of the System for safe, smooth, trouble-free operation and compliance with Local/International regulation is the sole responsibility of the MVAC Contractor i.e., the successful Tenderer. With this objective in mind, the Tenderer should include all the items essential for the efficient operation of the systems and other items which are required to complete the erection and foolproof commissioning of MVAC systems in respects. Whether the items are mentioned in the specification or not, all such items are treated/ considered to be included in the specifications.

4.2 Basis of Design

It is required to maintain conditions of comfort in the given specific areas as well as conditions favorable for the above building under normal load conditions and average lighting limits.

Proper heat load calculation shall be carried out to work out cooling load (RT) capacities of units and the nominal capacity of units shall be based on outdoor conditions.

Indoor design conditions shall be as follows:

Specified Area	Dry Bulb Temperature - °C	Relative Humidity - %	Sound Level – NR (dB)	Pressure
Cold Chain Facility Area	21.0 °C ± 1.0 °C	40-65	35-45	+VE
Vaccine Packing Area	21.0 °C ± 1.0 °C	40-65	35-45	+VE
Bio Medical Repair Room	23.0 °C ± 1.0 °C	40-65	35-45	+VE
Daycare Room	24.0 °C ± 1.0 °C	40-65	35-45	N/R
Feeding Room	24.0 °C ± 1.0 °C	40-65	35-45	+VE
Dedicated HVAC Control Room	24.0 °C ± 1.0 °C	40-65	35-45	N/R
Medical warehouse	24.0 °C ± 1.0 °C	40-65	35-45	+VE
Lobby	24.0 °C ± 1.0 °C	40-65	35-45	N/R
Meeting Rooms	24.0 °C ± 1.0 °C	40-65	30-35	N/R
Conference Room	24.0 °C ± 1.0 °C	40-65	30-35	N/R
Auditorium	24.0 °C ± 1.0 °C	40-65	30-35	+VE
Other Office Area	24.0 °C ± 1.0 °C	40-65	35-45	N/R
CCTV	24.0 °C ± 1.0 °C	40-65	35-45	N/R
Server Room	24.0 °C ± 1.0 °C	40-65	35-45	N/R
Panel Rm	24.0 °C ± 1.0 °C	40-65	35-45	N/R

Approximate Design Values

U-values for walls	- 2.56W/m ² K
U-values for Floor/Slabs	- 2.6 W/m ² K
U-values for Partition walls	- 2.2 W/m ² K
U-values for Glass	- 5.0 W/m ² K
Shading coefficient for Glass	- 0.7

The capacity of the unit shall be rated following AHRI Standard 1230 in ASHRAE 90.1-2022 and shall not be less than the minimum required when operating under the specified conditions. The capacity shall have to be suitably de-rated to consider any differences in level between the evaporator blower unit and the remote condensing unit and also the length of refrigerant piping involved.

4.3 Scope

The extent of work includes, however not limited to the following:

- (i) Supply and installation of VRV/VRF type air conditioning system (Including indoor units and outdoor units) having minimum cooling capacities as stipulated in the drawings and bill of quantities – Able to bear 5-10% fresh air as mentioned in the bill of quantities.
- (ii) Supply and installation of galvanized and stainless-steel ducting system complete with supply air grilles, supply air linear slot ceiling diffusers, return air linear slot ceiling diffusers, exhaust grills, fresh air intake grills (weather resistant type), motorized and manually operated volume control dampers, fire dampers, and guide vanes, etc.
- (iii) Supply and installation of fresh air intake louvres. It shall be weatherproof and constructed of extruded aluminium fitted with an insect net.
- (iv) Supply and installation of Air conditioning centre control panel in the relevant area with all accessories as stipulated in the bill of quantities.
- (v) Supply and installation of toilet exhaust ventilation fans and other ventilation fans as per the indicated in drawings.
- (vi) Supply and installation of HEPA filter, pre filters and bag filters as stipulated in the bill of quantities.
- (vii) Supply and installation of clean room applicable Air Handling Units (AHU's) to the cold chain facility area and vaccine packing area.
- (viii) Supply and installation of ventilation system for the material stores as per the indicated in drawings.
- (ix) Supply and installation of split air conditioning system as shown in the drawing.

4.4 Applicable Publications and Standards

Standards and Publications of the following organizations form part of this Specification to the extent indicated by the references thereto unless superseded by Detailed Technical Specifications.

ASHRAE	-	American Society of Heating Refrigeration and Air Conditioning Engineers
ASTM	-	American Society for Testing Materials
NFPA	-	National Fire Protection Association
ANSI	-	American National Standards Institute
SMACNA	-	Sheet Metal and Air Conditioning Contractor's National Association
ARI	-	Air Conditioning and Refrigeration Institute
AMCA	-	Air Moving and Conditioning Association
ASME	-	American Society of Mechanical Engineers
UL	-	Underwriters Laboratories
AFI	-	Air Filters Institute
IEC	-	International Electro-technical Commission
IEE	-	Institution of Electrical Engineers, UK

4.5 VRV/VRF Air Conditioning System

4.5.1 General

The refrigerating machine shall be delivered factory-assembled complete with all accessories and equipment such as water and refrigerant piping, valves, gauges, thermometers etc. required for convenient operation, testing and maintenance. Machines having valves, gauges, thermometers or any parts which shall be operated or inspected regularly and which cannot be reached readily shall be provided with platforms, ladders etc., with adequate handrails. Materials used in the construction of the machine shall be suitable for the purpose intended and those coming in contact with the refrigerant shall be highly resistant to corrosion by the refrigerant.

Refrigerant machines shall be reasonably quiet in operation. If noise levels in spaces subject to a noise guarantee included in the detailed specification are exceeded due to noises originating in the refrigerating equipment, the Contractor shall provide suitable acoustic treatment in the machine room to bring the noise levels within the specified limits without extra charge.

The refrigerating machine and connected system shall be fully charged with refrigerant and lubricating oil. Losses of refrigerant or oil occurring before acceptance of the

equipment, or occurring as a result of defects for which the Contractor is responsible under the guarantee, shall be made good by the Contractor at his own expense. Equipment necessary for safe and convenient charging of each machine shall be furnished complete, including weighing devices, visual indicators or other means of determining the correct charge, flexible connection, valves, gauges etc.

Heavy parts (25 kg or over) that must be removed for inspection, cleaning or repair, such as motors, gearboxes, cylinder heads, casing tops, condenser and cooler heads, etc. shall be provided with lifting eyes or lugs. A U-bolt shall be installed over the adjacent floor space. U-bolt shall be of ample size and securely fastened in a manner satisfactory to the Engineer.

Refrigerant-containing apparatus shall be constructed and provided with safety devices, in accordance with the latest edition of the ASHRAE Safety Code of Mechanical Refrigeration.

All refrigeration machines of similar type shall be supplied by one manufacturer. The electric motor starters, control gear and control equipment for sequence operation shall be supplied by the manufacturer of the refrigeration machines.

VRV/VRF Air Conditioning System shall be installed in conditioned areas.

The system shall be a VRV/VRF inverter-driven air conditioner for application with R407C/R410A or R-134A refrigerants. It shall be composed of ceiling-concealed ducted-type, ceiling cassette type and wall mounted type indoor units and air handling units with a distributed refrigerant cycle, electrical components and enclosing cabinets. The outdoor units shall be of the multiple compressor cabinet integrated type with inverter controls and completely weatherproofed for outdoor installation. Both indoor and outdoor units shall be properly assembled, internally piped and wired, tested and charged with the refrigerant at the factory.

As a standard of quality, the Contractor may use 'DAIKIN', 'Carrier', 'York', 'LG', 'Mitsubishi' or an approved equivalent make.

The scope of the above system shall include the following but not limited to the same.

- (i) Supply and installation of indoor units having the capacities mentioned in the BOQ with grouping outdoor units as per the drawings.
- (ii) Supply and installation of VRV outdoor units with the capacity mentioned in the BOQ and at the location which has been shown in the drawings.
- (iii) It was intended to group the indoor units as shown in the drawings and equipment schedule. The outdoor unit shall be a combination of fixed & variable speed units. The speed of the variable speed compressor shall be controlled through a solid-state inverter. The design of the inverter shall comply with IEC 555-2 & 555-3 concerning limits of total harmonic current &

voltage distortion created by the unit. These outdoor units shall be completed with combination units. The contractor shall select another single unit with having lowest capacity from the combination unit as a standby outdoor unit.

- (iv) Supply and installation of insulated liquid and gas refrigerant pipeline between indoor and outdoor units, condensate drain pipeline and ducting system for indoor units have been installed as shown in the layout drawings.
- (v) Each condensate drain line shall be connected to the wastewater riser inside the shaft by using a proper U trap or discharge to the outside and soakage to the premises as indicated in the drawing.
- (vi) Supply and installation of central monitoring and controlling network systems to monitor and control outdoor units and indoor units.
- (vii) Supply and installation of exhaust ventilation system with capacities stipulated in BOQ and drawings. All external static pressure levels shall be confirmed by the selected contractor before order placement for the Engineer's Approval.

4.6 System Description

VRV Air conditioning systems are provided for the complete building area as shown in the drawings. Air-cooled, Multi-Split, Variable Refrigerant Flow/Volume outdoor units coupled to the indoor units as indicated in the equipment schedule and drawings. The outdoor units for indoor units are installed on the roof terrace at the same building as shown in the drawing.

Refrigerant pipes and condensate water pipelines shall be installed as per the specified and manufacturer's recommendation. After doing the necessary connection the piping system shall be vacuumed and pressure tested before filling the pipelines with the refrigerant.

Each outdoor unit should have a separate control panel and shall be placed in locations as indicated in the layout drawings.

4.6.1 Indoor Unit

These indoor units are comprised of fan coil units (FCU) and air handling units (AHU).

The FCU units shall be of the Ducted Ceiling Concealed type, Ceiling Cassette Type, Wall Mounted Type. The cabinet shall be constructed of galvanized sheet steel, baked with synthetic resin paint, with a plastic air panel assembly. The refrigerant cycle shall be equipped with a heat exchanger, an electronic expansion valve, solenoid valves and flare connections. The fan shall be of the multi-blade centrifugal type, statically and dynamically balanced and directly driven by a motor of suitable capacity. The motor bearing shall be of the permanently lubricated type. The heat exchanger shall be of the

multi-pass, cross-finned tube type, equipped with highly efficient aluminium fins, mechanically bonded to seamless, oxygen-free copper tubes. The coil shall be cleaned, dehydrated and tested for leakage at the factory. All indoor units shall be fitted with condensate drain pump kits.

Fan coil units shall be supplied and fitted generally as shown on the accompanying drawings. Each fan coil unit shall be complete with fans, motors, filters, direct expansion coil, controls and all accessories.

Unless otherwise specified, fan coil units shall have non-decorative enclosures of 18 B.G. galvanized sheet steel. The fan units shall be so installed as to be easily and removable from the cabinet which shall be complete with front discharge and back return air duct flanges. The entire cabinet shall be insulated. Motor leads shall be terminated in an electrical junction box with multi-speed and off switch and control plate furnished for wall or surface mounting in the room.

Coils shall be of the extruded surface plate fin and staggered tube type and constructed of seamless copper tubing and aluminium fins and be complete with manual air vent and drain plug. The coil shall be suitable for the operating pressure and tested to 1.5 times the working pressure.

Fan coil units shall be selected based on medium speed operation of the fan and under this condition, the coil face velocity shall not exceed 2.6m/s.

Fan shall be of the double inlet, double width type with forward curved wheels of aluminium construction. Fan wheels shall be statically and dynamically balanced for true operation. Fans shall be direct driven by two bearings, and three-speed motors with a nominal speed not exceeding 1000rpm.

Fractional horsepower motors shall be permanent split capacitor type. Motors shall be equipped with sleeve bearings with oilers, and inherent thermal protection with automatic reset. Fans and motors shall be mounted on a galvanized steel fan deck with the assembly easily removable from the basic unit.

Each fan coil unit shall be internally insulated in accordance with the manufacturer's standard and adequate to avoid condensation. Where fan coil units are found to be unduly noisy, these shall be replaced at the instruction of the Employer's Representative. Before placing of an order for manufacture, the Contractor shall submit sound power level ratings to the Employer's Representative for review.

Condensate drain pans shall be of heavy gauge galvanized sheet steel designed for quick detachment from the base unit for servicing. Drain pans shall be insulated with a minimum of 15mm thick rigid insulation. Furthermore, the Contractor shall supply and install a secondary drain pan for the entire fan coil unit; this drain pan shall be constructed of a minimum of 18 B.G. galvanized sheet steel and suitably insulated, and hinged for easy access to the fan coil unit. The drain pans shall connect to insulated condensate drain pipes to discharge to the condensate drain pipe.

Filters shall be suitable for washing. Filters shall be supported on frames designed for quick detachment for servicing.

Each fan coil unit shall be provided with a thermostatic liquid expansion valve and a solenoid- operated valve or motorized valve with spring-loaded return, and built into the unit casing during or after assembly at the manufacturer's works. The valves shall be positioned in the pipe section and arranged such that it is not disturbed during the periodic removal for adjustment and cleaning. The automatic control and adjusting box shall be fitted in an accessible position near one of the inspection covers within easy reach for control and adjustment.

A wireless remote-control unit capable of controlling the following functions of the fan coil unit should be provided:

- Start/Stop of the fan coil unit
- Fan Speed
- Thermostat Setting
- Timer Setting

4.6.2 Air Filtration System

General

An air filtration system comprising of a primary filter shall be provided for fan coil units (FCU). The filter media consists of high-density, micro fine, glass fibre that shall be of non-combustible throughout or with exposed surfaces of Class O flame spread rating and shall not generate toxic gas when subject to heat or fire.

Each filter section shall be capable of handling the specified air quantity with a face velocity not exceeding 2.5m/s and its performance characteristics shall meet the requirements of ASHRAE 52-76, Method of Testing Cleaning Devices.

Filters shall be installed in accordance with manufacturer's recommendations complete with all accessories necessary for their proper performance.

Air filter connections to adjoining equipment, panelling or support framing shall be sealed airtight to ensure that no air bypasses the filter media.

The filter assembly shall be easily accessible for inspection, maintenance and

removal. Housing

Filter housing shall be factory fabricated and assembled of 16-gauge galvanized steel. The framework shall be sturdy galvanized steel angle members. Each housing shall be complete with two access doors, tracks, a holding frame and a pressure differential sensing device.

- Access Doors

Access doors shall be constructed of 16-gauge galvanized steel and positioned to facilitate easy removal and replacement of filters from either side of the housing. Each door shall be equipped with adjustable and replaceable positive sealing latches and replaceable hinges. Holding frame- to-door contact shall be provided with a tight gasket to affect a leakproof seal.

- Tracks

Tracks shall be field adjustable and replaceable and of heavy gauge anodized aluminium extrusion designed to accommodate filter-holding frames. Each track shall be equipped with replaceable felt stripes providing an air barrier between the track and the holding frame.

- Holding Frames

Holding frames shall be constructed of sturdy galvanized steel members and equipped with side channels, centring dimples, multiple fasteners and airtight gasket (internally and on frame sides) to facilitate a sealable side access system capable of accommodating any standard (nominal) 600 x 600 or 300 x 600 filters without modification to frame or housing. The filter media shall be held in position with PVC-coated heavy gauge galvanized iron wire mesh of mesh size not larger than 75 x 75 (mm).

- Air Filters for Fan Coil Unit

The filter shall be cleanable type mounted in a lightweight metal frame with media held in position with PVC-coated heavy gauge galvanized iron wire mesh of mesh size not larger than 75 x 75 (mm). All joints shall be fitted airtight with felt stripes. The complete unit including the filter box shall be suitably treated against corrosion. The face velocity of air passing through the filter shall not exceed 1.8m/s and the initial air resistance shall not exceed 0.4mbar.

4.6.3 Air Handling Units

Special Features for AHU's

Indoor Unit for Cold Chain Facility Area

Air-cooled, packaged, ducted, vertical and horizontal configuration, vertical and horizontal blow, air conditioner with series produced indoor unit as specified below complete with required accessories to maintain the given conditions for the chain facility area. Supply air ducts and exhaust air ducts as shown in the drawing.

- (i) Filter Banks consisting of pre filter, bag filter and HEPA filter
- (ii) Transfer air grilles and pressure dampers.
- (iii) Supply air grilles.
- (iv) Return air grilles.

a) General

The indoor units shall be suitable for Clean Room applications. It shall consist of (in the direction of air flow) a mixing box section, a filter section, a direct expansion type coil section, a heating coil section, a fan section and final filter section generally in accordance with the attached equipment schedules. The unit shall be supplied with galvanized and painted lifting assembly lugs located to suit optimum hoisting stability. This packaged type air conditioning plant shall be of the standard manufactured product and not of the locally modified type to meet the specified requirements.

The refrigerator shall be R 407C, R 134a or R 410a. The design of the air-handling units shall be based on the use of standardized panels of perimeter frames. The selection of the air handling unit's size shall be based on the airflow rate, coil face velocity and the allowable face velocity across the filters. To substantiate the selection the bidder shall attach his selection chart and technical literature of the blower and filters used showing their capacities. Further, computer selection charts shall be submitted.

b) Casing Construction of indoor unit

The following requirements specified in EN 1886 shall be met when designing the casing construction.

- Mechanical stability: at least class D2
- Casing air leakage: at least class L2
- Filter bypass leakage: max. 0.5% of the nominal flow rate
- Thermal transmittance of the casing: at least class T3
- Thermal bridge factor: at least TB4 to avoid condensation caused by temperature falling below dew point.

The units shall be of the double skin construction type and inner surfaces shall be smooth for easy and effective cleaning to reduce risk of dirt and bacteria accumulation. The casing shall have perimeter frame, with a wholly modular system based on standardized panel reinforced vertical sections. The panels shall be constructed such that they shall comprise of two layers of steel sheet sandwiching the non-hydroscopic, rot-resistant, 50mm thick polyurethane foam insulation (Thermal conductivity less than 0.02 W/mK, Density greater than 50 kg/m³) in between. The fixing of each panel to the perimeter frame shall be from inside the unit. No external panel fixings will be acceptable.

Exterior Panels

Exterior panels and frame surfaces shall be heavy gauged galvanized steel sheet coated with a highly durable factory applied, heat hardened polyester-based powder paint to thickness of 60 micron.

Interior Panels

Interior panels shall be made of stainless steel complied with EN 1.4301.

Lower part of the casing including slide in rails of components and all other surfaces which could potentially come in contact with condensation water, shall be corrosion resistant and made of stainless steel complied with EN 1.4301.

All components shall be removed through large doors.

c) Fan Section

The fan shall be of the forward curved centrifugal type (or backward inclined or airfoil centrifugal type). The blade of the forward curved wheels shall be galvanized steel. The blade of backward inclined or airfoil wheel shall be of heavy gauge steel, treated and painted after manufacture. Fans, intake flow nozzles and support structures shall be coated with hygienic epoxy resin. The fan assembly shall be statically and dynamically balanced to the fan operating speed range.

The fan motors shall be mounted inside the fan section on the fan base. The motors shall be of the totally enclosed fan cool (TEFC) type (or open drip proof type) suitable for use with 400 volts 3 phase 50 Hz electrical supply. Motor speed shall not exceed 1500 rpm.

Required static pressure to guarantee constant air flow as filters get progressively clogged shall be provided by Variable Speed Drive (VSD).

The fan drive package shall consist of VSD fan and direct driven, adequately sized to accommodate the application service factor.

The fan and motor assembly shall be mounted on a common base with factory supplied spring anti-vibration mountings sized to provide 95% vibration efficiency. The fan discharge shall be square (forward curved or backward inclined fans) or rectangular (for airfoils fan) in area and flanged and isolated from the casing by a flexible connection. Only one fan discharge shall be provided.

d) Cooling Coil

The coils shall be of the cartridge type, mounted over the condensate drain pan (for cooling coils) so that the complete assembly is wholly removable. Coils shall be tested at 2760 kPa air pressure whilst submerged in water. Coils shall be rated in accordance to ARI Standard 410.

Direct expansion coils shall have aluminium/copper fins with belled collars and bonded to 13mm OD copper tubes by mechanical expansion. Coils shall be provided with brass distributors with solder type connections and shall have a minimum of 2 distributors. Coils shall have full face active with inter winded circuits for equal loading on each circuit. Suction and discharge connection shall be on the same end. After testing the coil shall be dehydrated and charged with

dry air. Coils shall be designed and tested in accordance with ANSI B 9.1.

All coils shall have counter flow arrangements. The condensate drain pan shall be furnished with two-threaded pipe connections at both ends. The cooling coil and condensate drain pan shall be an assembly mounted on slides such that the cooling coil and condensate pan can be wholly removable to facilitate easy maintenance. Provide coil moisture eliminators when the coil face velocity exceeds 2.5 m per second. The eliminators shall have a minimum of 3 airflow direction changes. The number of rows of cooling coil shall be designed to suit the cooling /dehumidification requirement.

e) Heating Coil (Not Applicable)

The heating coil shall be of the electrical type and located on the downstream side of the cooling coil. It shall be either the open type or finned tubular type.

f) Filter Sections

The filter section shall consist of a pre filter section, and bag filter section.

The filter sections shall be supplied by the air handling unit manufacturer with the same casing construction as specified to the other unit sections. The type of filters to be housed within the respective filter sections shall be as specified below. Outdoor fresh air shall be pre-filtered using a filter of class G4 to EN 779 at the fresh air duct. The first air filter of class G4 to EN 779 shall be installed at the intake of the air conditioning unit. The second air filter of class F7 to EN 779 shall be installed after the first air filter.

High velocity filter section shall be capable of receiving 50mm thick filters of standard size low velocity filter section shall be capable of receiving 50mm deep filters mounted in 50mm width holding frames.

Bag filter section shall be capable of accepting a combination of 600mmx290mm or 600mm bag filters with length up to 600mm.

The overall air filtration efficiency of the system shall be 99.995% at MPPS (0.2 micron) at factory unidirectional flow supply air diffusers. The filter module shall be sized to suit the specified flow and the allowable flow capacity of the offered filter.

Each filter shall be equipped with an Electrical, constantly Monitoring, and Differential pressure sensor for clogged filter signaling by the microprocessor. The status of the filters shall be indicated in the BAS.

Third air filter of class H 14 HEPA to EN 1822-1 shall be installed after the Air Conditioner and prior to entering the factory processing complex.

Class H 14 HEPA Filters complied to EN 1822-1 shall be installed in Supply Air Duct and return air duct. Further, Bag in Bag Out (BIBO) type HEPA Filters with Pre-Filter

of Class F9 to EN 779 shall be installed in BSL-3 Laboratory Exhaust system and Microbiological Safety Cabinet Exhaust system. All filter Housings shall be made of Stainless Steel complied to EN 1.4301.

Each HEPA filter shall be shop tested and certified. Data such as air filter ID/designation, dimensions, serial number, filter medium, confirmation of the absence of leaks, removal efficiency, air filter class as per EN 1822-1, nominal volume flow rate, pressure differential at nominal volume flow rate, company and person in charge of measurements in date and place of measurements shall be included in the test certificate.

NOTE:

During and after defect liability period contractor shall responsible for check the filter clog status, safe removal and replacement of bag in bag out HEPA filters and disposal of used bag in bag out HEPA filters, adhering to standing procedures.

g) Compressor Assembly

The Compressors shall be high efficiency low noise Scroll type. Refrigerant shall be R407C, R134a or R410a. Compressor shall be semi-hermetic/hermetic type equipped with suitable vibration isolators, and shall be located in a sound-attenuating compartment within the cabinet. The compressor motor and miscellaneous piping shall be factory insulated by the manufacturer. Compressor shall be equipped with over current and over/under voltage protection devices. Cooling circuit shall be equipped with all the necessary controls, protections, safety devices, etc. and installed together with the electric panel and all other controls.

h) Access Section

Access section shall be supplied by the air handling unit manufacturer with the same casing construction as specified for the other sections. The access door shall be hinged and fitted with linear type door latches with inside safety release. The door shall be of double skinned construction and internally insulated with suitable glass wool/rock wool insulation.

i) Drain Pans-General

The condensate drain pan shall be made of stainless steel complied to EN 1.4301 of thickness not less than 1.5 mm. Casings shall be made of stainless steel complied to EN 1.4301 of thickness not less than 1.2mm. Casings shall be made in sections where required for ease in handling. All parts shall be heavily braced and stiffened to prevent vibration and hold all working parts rigidly on line. Casing sides shall be internally insulated on all surfaces between the cooling coils and the unit outlets. Insulation shall be of closed cell elastomeric foam with thermal conductivity less than 0.037 W/m.K at 32°C, density greater than 50 kg/m³ and anti-microbial additives. Insulation shall be secured to the casing with adhesive applied over the entire outer surface and shall be coated with a suitable coating such as plastic, or neoprene coating on the air stream side.

All seams and joints in insulation shall be completely sealed. The drip pan shall be adequately insulated, finished with a vapor barrier to prevent sweating. Drain piping from drip pans to nearest drain points shall be made by the Contractor, using hard P.V.C. type 600, minimum diameter 25mm with sufficient gradient to prevent overflow.

j) Seals

Seals shall be of detergent and glutaraldehyde vapour resistant closed cell elastomer.

k) Resistance to disinfectants

Air conditioning and ventilation components shall be resistant to conventional disinfectant agents.

l) Drainage system

The drainage system shall consist of a drip tray, a water seal borosilicate glass trap, sloped drainage pipe to remove moisture and an air break to ensure that once the moisture has been discharged to drain, that can't return to the plant.

m) Airtight Dampers

The air handling unit shall be equipped with integral, louvre-type, multi-leaf, motorized, airtight dampers on all openings for outdoor and supply air and they shall at least meet the criteria for tightness class 4 in accordance with EN 1751. They shall be automatically closed upon power failure.

n) Controller

Operation of the entire unit shall be managed preferably by a Programmable Logic Controller (PLC). Microprocessors shall manage all the operating and safety functions of the unit and provide controlling of temperature and relative humidity based on the information collected by remote sensors. Modes of the unit, normal operation / set back operation while maintaining required pressure and sterilization operation shall be managed by the microprocessor. They shall be called up manually, remotely or timely.

General AHU Description

Air handling units shall conform to **AHRI 430-2014** and shall consist, generally, of an air filter, cooling coils, fans, drip pans and casings. All AHUs shall be horizontal/vertical configuration as per the given spaces in AHU room. The capacities of the units shall not be less than specified and/or indicated on the drawings. The unit shall be fabricated from heavy gauge zinc phosphate coated sheet metal and finished in enamel and held together by bolts or clips to an all-welded galvanized steel frame. Joints between sections and components shall be used by means of gaskets or mastic sealants. The air handling units shall be constructed of double skinned insulated panels; inner and outer skin material shall be identical, the insulation material between the skins shall be mineral wool or similar material (Thickness of panel shall be manufacture

recommendation). Units shall be of the vertical top discharge type or horizontal discharge type, as indicated, with proper clearances for maintenance and replacement of parts.

All air handling units shall be factory made by the manufacturer. Only installation shall be required on site.

Coil rows shall be 4 or higher and coil construction as tube-copper, fins-copper/aluminum and frame shall be stainless steel. All the drain pans shall be Stainless steel.

All the AHUs target efficiency shall be 30% higher than the ASHRAE 90.1 latest one mentioned. CAV AHUs efficiency as 0.32 W/CMH and VAV AHUs efficiency as 0.47 W/CMH to be achieve when equipment selections.

All AHUs coils shall be tested for 16 bar.

Filters

Filters, media of fiberglass or synthetic Bag Filter complying to MERV 13 efficiency (MERV- Minimum Efficiency Reporting Value) and Pre-filters complying with MERV 8 efficiency shall be provided for the Air handling Units. Filters shall be selected at a maximum velocity of 1.5 m/sec, and if necessary be arranged in V-formation.

Filters are to be fitted in supporting frames with suitable provision for holding the cells securely in place without permitting leakage of air and arranged for convenient insertion and removal of filters from the side or the front according to accessibility.

The filter section shall be provided with a differential pressure gauge and the means to give an electrical signal when the pressure differential reaches a pre-set value.

The building shall be flushed out by using AHUs and the filters of AHUs shall be removed before flushed out the building.

NOTE:

During and after defect liability period contractors shall be responsible for checking the filter clog status, safe removal and replacement of pre and bag filters, adhering to standing procedures.

Fans

Fans shall be of the centrifugal type with one or more wheels of the forward or backward curved type mounted on a single shaft. Shafts shall be steel, either solid or hollow, and ground to close tolerances on all working surfaces. Shafts shall operate at least 25% below the first critical speed. Impellers shall be statically and dynamically balanced and tested to 125 percent of maximum design speed.

Bearings shall be of self-aligning, sleeve or ball type. Sleeve bearings shall be ring-oiled or wool- packed and provided with ample oil reservoirs. Sleeve bearings that are concealed within the unit casing shall be easily removable without removing the shaft from the unit and shall be provided with means for adding lubricating oil at a convenient point outside the casing. The oiling device shall be arranged so that oil can be added while the fan is running without danger of over oiling. Ball bearings shall be of the pre-lubricated, sealed type and shall have balls and races specially lapped and individually tested and selected for quiet operation and shall be rubber mounted, with suitable provision for earthing. Fans, intake flow nozzles and support structures shall be **coated with hygienic epoxy resin.**

Each fan shall be driven by a totally enclosed fan cooled type electric motor through a fully enclosed V-belt drive. The motor bracket shall be readily adjustable.

All AHU fans shall be controlled with VFDs (variable frequency drivers) and AHU fan motors shall be complying with this. The contractor shall submit AHU with fan and motor catalogs by giving evidence for this and ensure to select the AHU fan motors according to requirements.

Active Harmonic Filters of suitable capacity shall be provided to neutralize any Harmonics generated from the ***variable frequency drivers.***

Belt guard shall be arranged to permit oiling, use of speed counters and other maintenance and

testing operations with the guards in place. **The noise of the fan shall be less than 55 dB (A) at rated conditions.**

Drip Pans

Drip pans shall be made of galvanized sheet steel not lighter than 1.5mm. Casings shall be made of steel not lighter than 1.2mm. Drip pans and casings shall be phosphate treated and prime coated at the factory. Casings shall be made in sections where required for ease in handling. All parts shall be heavily braced and stiffened to prevent vibration and hold all working parts rigidly online. Casing sides shall be internally insulated on all surfaces between the cooling coils and the unit outlets. Insulation shall be of the rubber type, having a thickness not less than 1-inch and a density not less than 25kg per cubic meter.

Insulation shall be secured to the casing with adhesive applied over the entire back and shall be coated with an asphaltic, plastic, or neoprene coating on the air stream side. All seams and joints in insulation shall be completely sealed. The drip pan shall be adequately insulated, finished with a vapor barrier to prevent sweating.

Cooling Coils

Cooling coils shall be of the extended surface type, constructed of copper or brass tubing not less than ½ inch outside diameter, with helical or plate fins of copper or aluminum

extending at right angles to the tubes.

They shall be of the serpentine type and have inlet, outlet, vent and drain connection for each section.

Tube thickness shall be not less than 0.04 times the outside diameter. Tubes shall be soldered or brazed to headers unless the headers are thick enough or provided with bosses heavy enough to withstand, without undue distortion, the stresses due to rolling or expanding the tubes. Pressure parts of coils shall be constructed and tested for a pressure of not less than 15 kg per square cm.

Fins shall be spaced not closer than 1.8mm. Helical fins may be crimped or tapered. If crimped, they shall have a nominal thickness of not less than 0.18 mm and shall be soldered to the tubes. If tapered, they shall have a thickness of not less than 0.25mm at the base and shall be soldered to the tubes or wound with sufficient tension to insure permanent bond. Plate fins may be flat or formed and shall have nominal thickness of not less than 0.012 times the outside diameters of the tubes for aluminum and 0.008 times the outside to the tubes or shall be provided with integral spacing collars at least 3mm wide for full width of fin space, if less than 3mm into which the tubes are tightly and permanently expanded.

Each coil section shall be securely mounted in a die formed 1.6 mm thick, zinc coated sheet steel casing arranged for bolting to other sections, ductwork, unit casings etc.

Coil sections shall be supported on angle frames or other strings and rigid construction. Supports for cooling coils shall not pierce the drip pans and shall be arranged so that condensate cannot run down them past the pans. Support for cooling coils having zinc coated casings shall be zinc coated serpentine coils shall be accurately leveled.

Cooling coils should have sufficient area to prevent suspended moisture being carried into the air stream. Coils shall be selected for a maximum velocity of 2.75 m/sec.

Coils shall be suitably protected during shipment and installation so that fins and casing flanges will not be damaged. Coils having loose or damaged fins at the time of final inspection will be rejected and must be replaced with new coils.

A control valve with spring return with a matching thermostat must be provided for regulating the refrigerant flow through the coil in order to maintain the desired temperatures in the conditioned space.

A wired thermostat shall be provided for each & every AHU unit for temperature controlling. In case of power failures, the pre-set values must be retained, and the units should automatically restart on resumption of power supply.

Installation

Air handling units shall be mounted on vibration isolators placed on a concrete base to be made by the Contractor. The isolators shall be selected by the manufacturer of the air

handling units such that the isolation efficiency shall be at least 90% at the lowest disturbing frequency.

The piping connecting the cooling coils shall be sufficiently flexible and be flexibly supported to prevent the transmission of noise and vibrations of the air handlers to the building structure.

If there is not sufficient space available for a three-dimensional and piping layout, flexible metal hoses with corrugated bellows and braiding shall be used. The flexible hoses shall be factory made, flanged, and rated for a pressure of 10 kg/cm.

4.6.4 Outdoor Unit

“Factory coated Anti Corrosive” treatment (Blue Fins) for Al fins of Condenser Coils is mandatory and shall carry warranty of at least Five (5) years. The treatment should be suitable for areas of high pollution and marine category saline air.

The VRV/VRF outdoor unit shall be integrally built with multiple types of lightweight with weatherproof construction suitable for outdoor installation. The cabinet shall be constructed of galvanized steel sheet, baked with synthetic resin paint and weatherproofed as non-corrosive protection. The capacities of the units shall be carefully selected to match the grouped capacities of the indoor units. The service panel shall be easily removable for service access to the electrical components and the compressor section. Each refrigeration cycle shall be equipped with highly efficient compressors, solenoid valves heat protected against breakdown by quick response over current relays, high-pressure switches, wrap-around type oil heaters and a discharge gas thermistor. The outdoor fans shall be of the plastic propeller type and dynamically balanced. The heat exchanger shall be of the multi-pass, cross-finned tube type equipped with highly efficient aluminium fins, mechanically bonded to oxygen-free copper tubes.

The condenser fans shall be of the propeller or centrifugal type fabricated from plastic/aluminium alloy or other approved corrosion-resistant materials and shall be complete with non-corrodible bird screens. The fan motor shall be of the direct drive enclosed fan cooled weatherproofed type.

The condensing unit shall be complete with controls to provide proper sequence operation of fans, compressors, time delays between the starting of each motor and safety controls including cut-outs for high and low refrigerant pressures, low oil pressure and motor overload. Manual resets shall be provided for safety cut-outs.

The outdoor units shall be a combination of fixed & variable speed units. The speed of the variable speed compressor shall be controlled by means of a solid-state inverter. The design of the inverter shall comply with IEC 555-2 & 555-3 concerning limits of total harmonic current & voltage distortion created by the unit.

Each condensing unit shall be installed on two layers of ribbed neoprene pads separated with a sheet of steel, all similar to Mason-type WMW or equally approved. The Contractor shall select and install the unit to meet the noise criteria specified.

The efficiencies of the VRV outdoor unit shall meet the following minimum efficiencies as per ASHRAE Standard 90.1-2022 and AHRI 1230 specified conditions.

Total Capacity \geq 70kW

- Coefficient of Performance (COP) : ≥ 2.78
- Integrated Coefficient of Performance (ICOP) : ≥ 4.07

40kW \leq Total Capacity < 70kW

- Coefficient of Performance (COP) : ≥ 3.02
- Integrated Coefficient of Performance (ICOP) : ≥ 4.37

19kW \leq Total Capacity < 40kW

- Coefficient of Performance (COP) : ≥ 3.08
- Integrated Coefficient of Performance (ICOP) : ≥ 4.54

4.6.5 Electrical Work

All equipment shall be installed in accordance with the relevant British Standards or equivalent to the approval of the Engineer. Particular attention shall be paid to the protection of equipment during the construction period. The power supply shall be rated to 3 phase 400 V, 50 Hz. The Air conditioning contractor shall carry out all wiring from the 13A socket outlet close to indoor ceiling-mounted units and 3-phase isolators provided close to the outdoor units.

4.6.6 Vibration & Noise

The vibration and noise control of equipment installed are of prime importance. **The Contractor shall pay special attention to the problem of vibration and noise and is required to guarantee that the installation will not generate vibration or noise of the intensity to exceed the specified limits or cause annoyance to the occupants in the area. The contractor shall take necessary preliminary actions to avoid the spread of destructive noise levels more than stipulated in this specification and occupancy satisfaction. There are no approvals for variations regarding these noise issues once complete the MVAC system. Especially, contractor need to install internal soundproof insulations as mentioned in the drawings and bill of quantities.**

4.7 Selection of Air Conditioning Units

The Equipment schedule in the Table above was established during the design of the air conditioning system.

The Air Conditioning Units should be capable of achieving the following functional requirements

with specified equipment.

- Air-cooled outdoor units designed for variable refrigerant flow systems.
- Broad outdoor temperature operating range with 35°C DB maximum.
- Cooling capacity control capability ranging from 10% - 100% to suit the demand (Inverter / Multi Digital scroll compressors)
- Use of highly efficient inverter-controlled permanent magnet scroll compressors.
- Inverter frequency control range from 30Hz – 100Hz in 1Hz incremental steps.
- Refrigerant circuit with super coolers and sub coolers to improve performance.
- System reliability achieved by emergency operation of compressors and outdoor units.
- Controlled network system integrated with outdoor units and indoor units.
- Fine control of indoor temperature is achieved through electronically controlled expansion valves which control refrigerant flow to suit the demand.
- Simultaneous operation of 100% loaded compressors with capacity-controlled compressors to suit the demand.
- Centralized controller to connect the indoor units to each outdoor unit.

The outdoor Unit shall be mounted in an anticorrosive rust-resistant and galvanized steel plate casing.

4.8 Refrigerant Piping

4.8.1 Refrigerant Pipe Works

Refrigerant pipelines shall be sized in accordance with the manufacturer's recommendation and shall be hard copper tubes and meet the requirement of ASTM B 280 hard-drawn straight lengths. Soft copper tubing is not permitted. All outside refrigerant pipe works shall be properly covered by using aluminium cladding and outside trench pipe works and underground pipes shall be covered by more strength cladding material which is bearable to the high impact loads. These all cladding material shall be suitable for the high salinity environment usages without creating any corrosion surfaces.

4.8.2 Installation

Refrigerant lines shall be installed as high in upper mechanical areas as possible. All the connections of the refrigerant system shall be copper-to-copper type and brazed with specified rods. The brazing shall be carried out with the flow of Nitrogen gas inside the tube. Use flux only where necessary. No soft solder connections will be allowed in the system. Refrigerant support spacing shall be as follows. Shut-off valves shall be provided for both liquid and gas lines of each indoor unit to isolate from the system.

All supports for pipe shall be ferrous when electrolysis may occur between copper pipes and steel supports, the latter shall be fixed in the copper tubing using an insulating

material (neoprene, PVC, etc.,) to avoid direct metal contact. Hangers for pipe runs shall be of adjustable steel clevis type or other approved design hung on round steel rods. Brackets or clamps may be used where pipelines run along walls, columns or ceilings. A hanger shall be placed not more than 600mm

from each change of direction of pipes. All hangers and supports shall be hot-dipped galvanized for external use and shall be electroplated to adequate thickness for indoor use.

Soft-drawn small copper tubing for the pressure gauge shall be run on a 10swg galvanized steel channel, clamped but isolated by non-metallic sheeting.

Where possible, pipes shall be grouped on pipe racks made up of shaped steel frames securely fixed to walls, ceilings or beams. The pipes shall be supported by saddles or rollers, bolted to the racks.

Pipe hangers or supporting brackets shall be isolated to prevent transmission of noise and vibration to the building, especially in situations where these are connected to pumps and other sources of vibration, spring or rubber in shear hangers shall be used.

Support shall be **hot dipped galvanized** and designed and constructed in accordance with **ANSI/MSS SP-58, and ANSI/MSS SP-69.**

Pipe Sizes	Max. Support Spacing (m)
28 mm and smaller	1.8
32 mm and larger	2.4

A leakage test shall be made with nitrogen gas. The entire refrigerant piping network shall be filled with nitrogen gas, pressurized and end-plugged until the installation of indoor units, outdoor units, fresh air units and control devices to bring the entire system into working order.

4.9 Insulation

All refrigerant pipe work shall be suitably insulated with flexible elastomeric closed cell thermal insulation with a thermal conductivity (K) value not greater than 0.04 W/m°C, Density 50 kg/m³, class O type complied to BS 476 and vapour-sealed, including all valves, joints, and bends, etc. All refrigerant pipes shall be insulated to the following thickness:

Pipe Sizes	Thickness
19 mm and smaller	19 mm
22.2 mm and larger	25 mm

4.10 Refrigerant Piping - Testing and Commissioning

The testing and commissioning shall include purging the refrigerant pipelines using Nitrogen gas, vacuuming the refrigerant pipelines, pressure testing the refrigerant

pipelines & drain pipelines and filling the refrigerant pipeline with nitrogen gas and end-plugging the pipes.

4.11 Test Instruments

Technical literature of all testing instruments proposed to be used in testing inclusive of drawings, capacity, tables, test reports, test certificates from relevant local authorities and other relevant information shall be supplied in triplicate for the Engineer to determine the adequacy and suitability of the testing instruments.

4.12 Test Pressure

Refrigerant piping shall be tested by filling the system with dry nitrogen to the required pressure and all joints inspected with a halide torch to check for leaks. A test pressure of 1.5 times the maximum service pressure shall be maintained for 24 hours. Pressure drops of more than 2% over the 24 hours shall not be accepted.

Refrigerant pipes, ref nut joints and shut-off valves shall be capable of withstanding a test pressure of 550 psi.

4.13 Condensate Drainpipe Works

Condensate pipes shall be of u-PVC type 600 and drain work shall be provided with matching fittings, U-traps, cleaning eyes, vents, etc as required and as per drawings. A sufficient gradient (1:30) shall be maintained in the horizontal pipe network to facilitate the gravity flow. The drainpipe work shall be insulated with closed cell flexible foamed type insulation with not less than 19 mm thickness. The condensate drain risers shall end at a wastewater/stormwater catch pit as per the site condition.

4.14 Factory Inspection and Tests

The following tests and checks shall be carried out in the manufacturer's works and test certificates issued by an approved Testing Authority shall be submitted.

- All tests as required by the manufacturer's practice or applicable standards during the manufacturing stage.
- VRV/VRF units Performance Test in accordance with international stranded requirements at the stipulated testing procedure at part load points.

4.15 Duct Work and Air

Terminals 3.15.1 General

Unless otherwise specified or noted casings, plenum chambers and ducts shall be made of type **304L, Stainless Steel Sheet** for the cold chain facility and vaccine packing area.

Unless otherwise specified or noted casings, plenum chambers and ducts shall be made of **hot dipped galvanized steel** for other areas.

All ductworks shall be braced and stiffened so that they do not break, rattle or vibrate. The bracing shall be applied on the outside of the ducts. All ducts shall be constructed using **continuous Welded Construction**.

Fittings shall be fabricated from type 304L, Stainless Steel Sheet with seams continuously welded. The metal thickness shall be a minimum of two sizes thicker than the duct thickness. (For cold chain facility area) Segmented 90 degree bends shall be five section elbows. Segmented 45 deg bends shall be three section elbows. Bends shall have a ratio of centerline radius to diameter of at least 1.4 to 1. All tees shall have conical or tapered branches.

In the air conditioning plant rooms, the ducting shall be fabricated in flanged sections, bolted together, utilizing cadmium plated bolts and screws for easy dismantling.

The construction of ductwork shall be generally in accordance with the Duct manual and Sheet metal Construction for Ventilation and Air conditioning Systems", published by the Sheet Metal and Air conditioning Contractors National Association Inc. U.S.A. (SMACNA).

Measuring holes with cover plates are to be provided for the use of Pitot Tubes, deflecting anemometer for measurement of air quantities. Such holes are to be provided at convenient positions to facilitate regulation of all branches and as may be required by the Engineer.

All joints in the insulation shall have a minimum staggered lap length of 2". All edges shall be sealed with 2" wide aluminum self-adhesive tape.

Duct work shall be completed with accessories such as fire dampers, access door shall be clear wired glass vision panels. Ducting shall be made airtight for maximizing energy efficiency of the system. Adequate numbers of volume control dampers will be provided to ensure ease of balancing of the airside. Splitters shall be installed for all bifurcation of ducts.

The complete system shall be thoroughly cleaned and disinfected, on completion of the installation and once again just prior to the laps of the free maintenance period. Marked access doors will be provided to ease future cleaning and disinfection. A fresh set of all air filters will be installed prior to the system being handed over after the defect liability period (probably after one Year)

All external ducts of supply air and return air shall be covered with Gypsum box covering as approved by the Engineer.

Duct sizes, ducting material, fittings for ducting systems, sound attenuating materials, size of sound attenuators shall be revived and decided to maintain the specified sound pressure level inside the building by the Contractor.

Ductworks discrepancy between actual installation & design drawing of less than 5 meters shall not be considered as variation.

3.15.2 Sound Attenuators (Absorbers)

The sound absorbers at the intake and supply side of the fan coil units or air handling units (supply and return ducts) shall be constructed according to the latest Engineering practice.

The sound-absorbing lining material shall impart no odour to the air, shall not delaminate readily and shall have no loose material on any exposed surface that may be detached by the air stream, either during installation or under regular operating conditions. The material shall be non- combustible. Sound-absorbing material contact with the air stream shall be neoprene coated.

All lining material shall be in good condition at the time of final inspection. Material that has been damaged in shipment by handling, vibration or exposure will be rejected. Material shall be replaced or coated to prevent detachment of loose material as directed by the Engineer.

The sound-absorbing lining material shall be adequately secured and protected. Edges of material that are not protected by metal shall be heavily coated with adhesive to prevent detachment of loose material, whether such edges are to be exposed in the finished assembly or butted against other similar edges.

The thickness of sheet metal for ducts having sound-absorbing linings shall be as specified for other ducts except that they shall be based on the actual metal duct dimensions and not on the clear inside dimension shown on drawings and shall in no case be lighter than 0.7mm for low- pressure ducts and 0.9mm for medium pressure ducts.

Casings shall be made of zinc-coated steel, not lighter than specified herein for ducts of the same outside dimensions, but in no case lighter than 0.7mm for low-pressure ducts and 0.9mm for medium-pressure ducts. Casings shall be suitably braced and sealed so as not to show any distortion or leakage.

Sound absorbers in the ducting penetrating the walls or floors of a plant room shall be mounted with a flanged end against the wooden partition surrounding the duct passage and be sealed with mastic to prevent plant room noise from being transmitted to the occupied areas.

3.15.3 Flexible Ductwork

Flexible Ductwork shall be provided where shown on the drawings and for connection of ductwork to plenum boxes associated with diffusers and grilles. Flexible Ductwork shall be pre- insulated / neoprene material of approved type with 25 mm thick glass or mineral insulating blanket with 32 kg/m³. Insulation/Blanket shall be sheathed in a

flexible reinforced Mylar- aluminum foil jacket (vapour barrier). The minimum length of the flexible duct shall be less than 0.5m. Flexible connections shall be renewable without dismantling the ductwork which shall be suitably supported adjacent to all flexible connections and shall be designed for the air pressure involved. They shall generally have a length of 100 to 150mm and shall also reduce noise breakout by having a mean sound reduction index of not less than 22 dB in the 100 to 3200 Hz range.

Metal straps of width and spacing to the manufacturer's recommendation to be used.

3.15.4 Duct Supports

A pair of hangers shall be located close to each transverse joint and elsewhere as required by the spacing indicated in the tables.

Hangers shall be spaced not more than 3000 mm. apart and at changes of direction. Types and construction of hangers shall be as detailed on the Drawings and in compliance with SMACNA /DW recommendations. Channels and rod Support shall be Hot dip Galvanized.

Support shall be **hot dipped galvanized** and designed and constructed in accordance with **ANSI/MSS SP-58, and ANSI/MSS SP-69.**

Maximum spacing between hangers	
Duct Size	Space
Less than 1500	2400 mm
1600 to 2500	1800 mm
Exceeding 2500	1200 mm

Flexible Duct Support

Metal straps (hot dipped galvanized due to high salinity environment) of width and spacing to the manufacturer's recommendation to be used.

Horizontal Ducts

Generally, all horizontal ducts shall be supported by trapezes hangers with angle supports and steel rod hangers in accordance with the table below:

Dimension of longest side of duct (mm)	Angle Support (mm)	Steel rod hangers (mm)
UP TO 450	25 X 25 X 18 B.G. (1.257 MM) galvanized sheet steel angle-hammed	6

451 TO 750	25 X 25 X 3 angle iron	6
751 TO 1500	40 X 40 X 3 angle iron	10
1501 TO 2400	50 X 50 X 6 angle iron	13
OVER 2400	50 X 50 X 6 angle iron	13

The upper ends of hangers shall be vertical and secured individually to the floor of the roof construction above. Hangers shall not be secured to suspended ceilings, suspended ceiling hangers or insertions to which suspended ceiling hangers are attached.

If required, vibration isolating hangers, supports and metal sleeves with mineral fibre packing (passing through walls) shall be provided for all duct works installed inside the ceiling voids to prevent the structural born vibration transfer to the building.

The Material specifications for construction of the sheet metal ducting will be as follows.

Max. Side Dimension of Duct in mm	GI Sheet thickness in mm	Type of Transverse Joint Connection	Bracing
Up to 450	0.8	S, drive slip ,pocket slip, or bar slip	None
450 to 1200	1.0	Hemmed S, pocket slip , or bar slip	25 x 25 x 3 mm Angles at 1200 mm centres
Over 1200	1.2	50 x 50 x 4.5 mm. angle with gasket.	50 x 50 x 4.5 mm angle at 600 centres

The following variations from the above will be accepted.

- Ducts where the larger dimension does not exceed 750 mm, cross bracing will be accepted in place of the angle iron bracing.
- Proprietary duct connection different to the above will be considered if the manufacture's recommendations are strictly adhered to. The Consultants approval for such connection must be obtained in advance after submitting all the necessary technical data.
- A round duct fabricated out of GI sheet conforming to the above is accepted wherever possible in order to save limited spacing.

All ducts shall be adequately supported using steel hanger rods and supports. All horizontal runs of ducting shall be supported as follows. The hanger rods shall be of

minimum diameter of 6 mm.

Cross sectional perimeter of Duct in mm

Maximum spacing between hangers	
Less than 1500	2400mm
1600 to 2500	1800mm
Exceeding 2500	1200 mm

Fresh air supply duct need not to be

insulated. Sheet metal Ductwork

All ductwork is to be manufactured from best quality zinc coated galvanized sheet metal in accordance with Clause D of B.S. 2989- 1967. The zinc coatings must not be damaged during formation and erection. No metal may be used internally or externally for fixing, bracing, stiffening, etc., which will cause electro-chemical action with the ductwork in the presence of moisture.

Special care shall be taken to ductwork supports and fittings where air velocities exceed 10m/s or where the overall duct system static pressure exceeds 0.5 kPa.

The Contractor shall in all cases ensure that sufficient bracing is provided to prevent sagging, drumming or vibration of ductwork.

All fixing of hangers supports and brackets to the building structure shall be by means of approved metal expansion plugs in accurately drilled receiving holes. The use of explosive charge or velocity driven fixing studs can only be used with specific approval of the Employer' Representative.

The ductwork drawings are indicative only; positions of the ductwork, grilles and diffusers shall be finalized after coordinating with other services. In plan drawings, dimensions are given thus: horizontal (width) X vertical (height) clear. The Contractor shall take into consideration of duct insulation and fire rated board while accessing space for installation of ductwork.

The Contractor is required to ensure that the diffusers supplied shall match and be suitable for the ceiling grid system to the Employer' Representative's detail and shall offer equipment to ensure a neat appearance consistent with proper functioning of air distribution.

All weatherproof intake and discharge air louvers on external walls/building fabric as shown on the drawings shall be supplied and fixed by the Contractor to the Employer' Representative's detail and approval unless otherwise specified.

All joints and seams shall be made air-tight by welding, soldering or use of sealants. Except on flexible ductwork, liquid sealants shall not be used. Mastic sealant where required shall be applied by a pressure gun where possible to inside of the assembled

joint. Oil based caulking or glazing compound shall not be used. Gaskets may be of soft neoprene, or other material to approval.

All dimensions shown in the drawings are clear internal sizes. Where internal insulation is used, the thickness of the insulation must be added to the dimensions shown in the drawings to determine the actual size of the metal duct.

Ductwork for rectangular sizes shall be free of any waves or buckles and all sheets, except in the case of round ductwork, shall be machine bent to ensure Neat Square and precise fabrication.

Ductwork shall be provided with flanged connections in plant rooms to allow for easy removal for future replacement of equipment.

All ductwork not insulated shall be painted externally to the approval of the Employer's Representative. All duct surfaces behind registers, diffusers and grilles within the line of sight shall be painted matt black internally.

All casings, housings, plenums and chambers in low or medium pressure systems, having greatest dimensions between 1050 mm and 1500 mm shall be not less than 18 gauges.

All casings, housings, plenums and chambers in low or medium pressure systems which exceed 1500 mm in any dimensions, shall be not less than 16 gauges.

All ducts over 450 mm in either direction shall be cross braced or bracing, excepting those to which rigid board insulation is attached.

No pipes shall pass through ducts, unless deemed necessary by the Employer's Representative. Where pipes are shown to pass through ducts, the Contractor is to provide tear-drop sheet metal fairing, carefully shaped around pipes, seal ducts at junctions.

For square elbows, long tail pattern turning vanes, spaced 38mm on centres for duct sizes up to 600mm in width and 81 mm for duct sizes 625 mm and over. The tangent portion of the tail of each vane shall be half again as long as the arc. In high pressure systems use vanes having aero foil form.

Ductwork shall be of low, medium or high pressure design. Systems with static pressure after an discharge up to 50mm WG shall be considered low pressure; 51 mm to 100mm shall be considered medium pressure; above 100mm shall be considered high pressure.

Grilles and diffusers are to be supported from soffit of slab with approved hangers. Supports shall have adjustment to allow final positioning of diffusers/grilles accurately in ceiling.

Duct Construction Table

Rectangular Ducts

For low pressure rectangular ducts where air mean velocities are less than 10 m/s and

static pressure in duct does not exceed 0.5 kPa such ducts shall be constructed of galvanized sheet steel in accordance with the table below: -

Dimension of longest side & duct (mm)	Sheet Steel Gauge (B.G.)	Type of Transverse Joint	Reinforcing angle size & maximum longitudinal spacing between transverse joints and / or intermediate reinforcing
1501 to 2100	20 (.996mm)	40 x 40 x 3 angle flanged connection all sides	40 x 40 x 5 angle @ 600 centres
2101 to 2400	18 (1.257 mm)	40 x 40 x 5 angle flanged connection all sides	40 x 40 x 5 angle @ 600 centres
Over 2400		50 x 50 x 6 angle flanged connection all sides	50 x 50 x 5 angle @ 600 centres

Circular Ducts

For low pressure circular ducts where air mean velocities are less than 10 m/s and static pressure in duct does not exceed 0.5 kPa such ducts shall be constructed of galvanized sheet steel in accordance with the table below:-

Diameter of duct (mm)	Sheet Steel gauge (B.G.)	Type of Girth Joints	Type of Girth Reinforcing
Up to 330	26(0.498mm)	Beaded and solid Riveted Slip joint, minimum 100mm long	None Required
331 to 560	24(0.629mm)	Beaded and solid Riveted Slip joint, minimum 100mm long	None Required
561 to 900	22(0.794mm)	32 x 32 x 3 angle flanged joint	32 x 32 x 3 angle at 1800 centers
901 to 1300	20(0.996mm)	32 x 32 x 3 angle flanged joint	32 x 32 x 3 angle at 1800 centers
1301 to 1500	18(1.257mm)	32 x 32 x 3 angle flanged joint	32 x 32 x 3 angle at 1800 centers

Materials and Construction

1.Low Pressure Ductwork

Refer to table for ductwork construction for method of fabrication.

If the physical space available prohibits the use of angle flanges, approval must be obtained to use drive slip joints suitably stiffened at a maximum of 1.2 m centers, and leak proof by the use of sealants.

Angles shall be fitted with rivets at 80 mm centers. All circumferential joints shall be made airtight with special attention given to corners. Angle corner pieces shall be used or drive slip joints and where necessary, corners are to be soldered or sealed by other approved means.

All flange joints shall be fitted with neoprene rubber gaskets, or APPROVED equal, approved in writing.

All large ducts with a width/depth ratio greater than 4:1 and width greater than 600 mm shall be internally stiffened to prevent sagging. Stiffeners shall be 32 X 5 mm angle iron bolted to the duct with 6 mm galvanized bolts and nuts spaced at 0.9 m centers between angle stiffeners.

Unless otherwise specified, all changes in duct size shall be made in a gradual manner with a tapering subtended angle of 15 deg. or less. Bends shall be made with an inside radius not less than the duct width in the plane of the bend, bends of smaller radius may be used with the approved turning vanes.

At all flanged connections, the angles shall be riveted to duct at not more than 65 mm centers with mastic material between angles and the sheet metal. The one coat of anti-corrosive paint before they are bolted together. Angles in flanges shall be welded at the corners.

As specified in D2 in addition to flange joints where are to be made air tight by the use of jointing gaskets (para above), all longitudinal joints rivets, bolts, etc. must be made air tight by the use of sealants applied both before and after fabrication.

Test points shall be provided at the discharge of each packaged unit and at each discharge of terminal boxes and individual zone or branch handling 10% total air of the ductwork system to ensure pilot tube or voltmeter reading to be taken. Test points shall consist of 25mm diameter sockets fitted with removable sealing plugs for fitting of measuring devices. Test points shall be insulated as for the ductwork and shall be provided with identification metal labels. Test holes shall be located at a point of minimum turbulence and in accordance with B.S. 848.

Flexible Connections

Flexible connections shall be fitted at all expansion and settlement joints in the building structure, equipment connections, inlet and outlet of all supply and exhaust fans, on fan coil units where these connect to ductwork, and at all sound attenuator connections.

Flexible connections shall be renewable without dismantling the ductwork which shall be suitably supported adjacent to all flexible connection shall be designed for the air pressure involved. They shall generally have a length of 100 to 150mm and shall also reduce noise breakout by having a mean sound reduction index of not less than 22 dB in the 100 to 3200 Hz range.

Flexible connections shall be constructed from neoprene material of approved type and insulated with foil back 25 mm thick fiber glass blankets.

Joints shall be installed to ensure careful alignment of adjacent joints and to prevent air leakage. Each flexible connector shall be fastened tautly to matching flanges by 2 pieces of adjustable clips/clamp bands.

In critical location where noise breakout must be controlled, special joints having the correct sound breakout alternating properties must be used.

For ambient air temperatures, flexible connectors shall be of loaded PVC on a jute base, approximately 3 mm thickness and having surface density not less than 5 kg/sq.m.

For high temperature or smoke extract application, fire retardant type flexible connector shall be fitted. They shall be made from loaded PVC on woven asbestos base, of a minimum 3 mm thick and rated Class 2 when tested to B.S. 476 Part I, 1953 surface spread of flame. Manufacturer test certificate be provided on request.

Sealants

All joints and seams shall be made air tight by soldering or the use of sealants.

Sealant must be of type approved by Authorities. Gaskets may be soft neoprene or extruded forms of sealant.

All sealant type joints shall be covered with tape of an approved type compatible with sealant.

Duct Supports, Hangers and Opening

a. General

I. All ductwork shall be securely supported so as to prevent vibrating movement, but allow expansion due to thermal stresses without distortion of the ductwork, rupture of insulation or damage to the supporting structure.

II. All ducts are to be suitably supported at intervals according to size and construction, with approved hangers, cradles or angle iron supports. Where ductwork is supported from below, neat angle iron supports shall be used. Supports shall be hot dipped galvanized after fabrication. Internal support shall be coated. Generally, supports shall be spaced 1.2 meters apart but where larger ducts are concerned, the spacing shall be

reduced to 0.6 m apart. Where the ducts change directions or split, support shall be required regarding distance from preceding support.

- III. Where ducts pass through floors and walls, the clearance space shall be caulked tight with approved material and a close-fitting metal angle flange fitted to cover such clearance space.
- IV. The Contractor shall provide an access door to each duct in which dampers are located.
- V. The steel straps used for hangers shall be 25 mm x 3 mm for a maximum duct size of 760 mm and 32 mm x 3 mm for duct size above 760 mm, painted with aluminum bitumastic paint before installation.

Vertical Ducts

Vertical ducts shall be rigidly supported at least at each floor level and at a maximum of 3.6m spacing. Supports shall be structural angles or channels fixed securely to the duct and structure in an approved manner.

High velocity ducts support shall be isolated from the duct by means of 12 mm thick neoprene pads or equivalent.

Low Velocity Ducts

Ducts up to 450 mm width may be suspended by means of 'U' shaped flat iron hangers taken around the bottom of the ducts and secured on each side and bottom by bolts.

Flat iron hangers to be used for wider ducts by fixing to duct stiffening angle frames.

Hangers shall be 25 x 3 mm flat bar up to 750mm maximum side and 40 x 3mm bar for ducts above 800mm maximum side. Where ducts run at floor level, they shall be supported on 50 x 50 x 6mm angle iron saddles bolted to the floor. The ducts shall be held in the saddles by 40 x 3mm flat iron bolted to the angle supports.

Load spreader sheet of dimension and thickness to approval must be used between the duct insulation and hangers if used outside the insulation.

3.15.5 Air Terminals

All samples of the proposed diffusers/grilles shall be submitted to the Engineer for approval before installation together with the aerodynamic and acoustic performance sheets of those and sizes be selected according to the manufacturer's recommendation ensuring low noise, and low stratification.

The contractor shall submit a sounder pressure level profile for all types of diffusers and grills specified under this project.

The Contractor shall provide and fix all necessary supplies and extract diffusers and

grilles as shown on the drawings. All fittings shall be capable of adjustment by means of a key operated opposed blade multi-leaf volume damper to achieve correct air flow and the design and type of fitting must provide correct air distribution, diffusion and air movement within the space served without creating objectionable noise, chatter and draft.

All air diffusion equipment shall be selected for quiet operation when handling the specified volume of air and shall provide uniform velocity across the face. Openings in ducts to receive air diffusion equipment shall be reinforced around the perimeter and gaskets shall be used to prevent leaks at the necks or around the air diffusion equipment.

Where the grille, diffuser or register finish is unspecified, the finish shall be painted a colour as approved by the Employer's Representatives and/or Consulting Engineer. All internal surfaces of grilles, diffuser registers and concealed damper units shall be coloured by the approved colour.

All supply grilles, diffusers, etc. shall be erected square and level and accurately set out as to spacing. All fittings shall be mounted on substantial wood/metal frames and shall be provided with 6 mm soft neoprene or framed, to eliminate air leaks.

Before any diffusers etc., are ordered or the manufacture of fittings commences, confirmation must be obtained from the Employer's Representatives and/or Consulting Engineers as to the exact position type, design and finish required.

Samples of every type of grille, diffuser, etc., are to be submitted to the employer's representatives and consulting engineers for approval before orders are placed.

All fittings shall be of Airmaster, Beta, Betec or Titus make, as specified, or approved equivalent.

All air transfer louvres and grilles on doors and all external weatherproof louvres shall be supplied and installed by the Contractor.

Supply Slot diffuser And Return Saddle Troffer

- The casing shall be fabricated from 0.56 mm THK electro/hot dipped-galvanized steel c/w 12 mm THK internal thermal & acoustic insulation fiberglass 32 kg/m density. Faced with a mat to prevent erosion of fiberglass by moving air.
- The volume control damper shall be of ice-tong type and shall be adjustable from below the slot permitting 180 deg. Adjustable air pattern from horizontal to vertical to opposite horizontal, without having to dismantle the ductwork or fitting.
- The inlet collar to the air boot provided shall be a side or top inlet and

shall be of round collar.

- Supplier shall provide air performance data rated in accordance to ADC test code and ASHRAE Standard.

Square Diffusers

The square diffusers shall have a four-way appearance with fixed blades and a removable core for horizontal air discharge.

The diffusers shall be chosen to have a flush finish with the ceiling. A supply air plenum box constructed of galvanized sheet steel shall be provided with a circular side entry connection. The duct connection shall limit the maximum inlet air velocity to 3.0 m/s. The maximum height of the plenum shall not exceed 400mm. The connection of the diffuser to the plenum box shall be by use of a concealed type fixing.

Where a smaller diffuser face size is required for low supply air flow rates, either the plenum box or the back of the diffuser shall incorporate a fixed metal plate to blank the diffuser to the required size.

Where three, two or one-way throw supply diffusers are required, they shall have the 4-way appearance and incorporate a metal blanking plate fixed as described above. The square-type diffuser shall also be used for returning into the ceiling void.

Type of Construction of Fittings

- All grilles or diffusers are to be constructed of anodized aluminium.
- Side wall supply grilles are to be constructed with two sets of blades each being individually adjustable, the front set of blades is to be vertical unless otherwise stated. Keys are to be provided for adjustment, no projecting adjusting device is permitted. Vanes shall be spring-loaded, friction-held, or otherwise arranged so that they remain permanently in their position without vibration or noise. Vertical inter-supports are to be provided for horizontal blades to ensure that no sagging occurs.
- Side wall return air grilles are to have one set of horizontal blades only.
- Dampers - All supply grilles are to have opposed blades volume damper fitted capable of external adjustment.
- Ceiling-type supply diffusers - these shall be of louver face type and equalizing grids suitable for surface mounting. Generally, these shall have 4-way blow or otherwise shown on the drawings and neck

velocities below 150 m/min. Each diffuser shall be supplied with opposed blade volume damper, capable of external adjustment.

- Linear diffusers -these shall be of robust extruded aluminum suitable for surface mounting with volume control dampers and directional control. These shall generally be of one- or two-way blow pattern.
- Air supply boot outlets are to be provided with 25 mm foil backed external thermal insulation. The joint in the boots must be sealed with suitable and approved fire rated compound. All materials used shall comply with the requirements of FSB. The volume control damper shall be fitted at inlet collar, friction held and adjustable from the boot opening below.
- Painting - All diffusers, registers and grilles shall be prime coated with best quality rust preventive primer and then painted flat-grey enamel. Final colour enamel coated to be decided by the Employer' Representative.

Linear Slot Diffusers

The slot diffuser shall be constructed from high-quality stainless steel (Grade 304) / powder coated aluminum finish with a polished or satin finish, ensuring durability, low microbiological growth surface and corrosion resistance.

Diffusers shall be of the linear type as indicated on drawings. Diffusers shall be sized in accordance with the recommendations of the manufacturer and shall be guaranteed to deliver the air quantities indicated and maintain the noise level as stipulated in the specification.

Supply diffusers shall be equipped with baffles / hit & miss dampers or other devices necessary to provide the distribution pattern that will meet the above-specified performance while return diffusers shall not be equipped with hit & miss dampers. Straightening vanes shall be provided in the necks of diffusers unless the connecting elbow is of the vaned type or the omission of the vane is necessary to produce the required distribution pattern. Vanes shall be installed so that they can be removed through the diffusers for access to the duct. Surface finish shall be powder coated with architect approved colour.

Diffusers shall be rigidly constructed out of 1.0 mm thick galvanized steel sheets and all edges of metal exposed to view shall be rolled or otherwise stiffened and rounded. All internal parts of each diffuser shall be removable as a unit to permit cleaning of the diffusers and provide access to the ducts.

Jet Diffusers (Not Applicable)

The jet diffuser shall be constructed from high-quality stainless steel (Grade 304) with a polished or satin finish, ensuring durability and corrosion resistance. It shall be designed for high-velocity air supply, with an adjustable core allowing for directional airflow control up to 30° in all directions. The diffuser shall be suitable for long throw applications in large spaces such as auditoriums, halls, and industrial facilities. It shall be mounted on circular or square flanges, compatible with both ducted and plenum installations. The unit shall comply with ASHRAE and SMACNA standards for air distribution performance and noise control.

Return/Supply air linear bar Registers/ Grills

Return/Supply air linear bar registers and grills will be sized in accordance with the recommendations of the manufacturer and shall be guaranteed to deliver the air quantities indicated. Grilles and frames shall be made of Anodized Aluminium.

Return/Supply air linear bar registers and Grills shall be equipped with baffles or other devices necessary to provide the distribution pattern and required air quantity that will meet the above- specified performance.

A sample of the proposed grills and registers shall be submitted to the Engineer for approval before installation.

Exhaust Air Grilles

Exhaust Grilles and frames shall be made of Anodized Aluminium, joined and ground flush at the corners or provided with neat trim. All exhaust grilles shall have felt or sponge rubber sealing strips at all edges.

Anodized Aluminium Grilles shall be factory finished. The colour is to be the approved by the Architect.

Weather Resistant Louvers

Weather resistant louver will be sized in accordance with the recommendations of the manufacturer and shall be guaranteed to deliver fresh air to FCUs and exhaust air from exhaust fans and rooms to outside environment. Louver shall be connected to duct work, with fixing material and it shall be made of Aluminium. It shall be constructed with accurately fitted blades having folded edges, to exclude driving rain and shall be securely mounted on the outside wall and it shall consist of a wire mesh screen and a washable filter.

The type, colour, construction and location shall be subject to

approval. Disk Valves

The disk valves consist of the valve ring and central disc. To guarantee a perfect seat,

the valve ring is fitted with a peripheral sealing strip. The air volume flow rate is adjusted by rotating the central disc which alters the size of the gap. The central disc is held in position with a locknut.

3.15.6 Air Control Dampers

Balancing Damper / Volume Control Dampers

Volume dampers shall be of the butterfly type for ducts 380 mm in depth and lower. Multiple opposed blade types for ducts above 380 mm in depth. The maximum blade sizes shall be 1220 x 250 mm. For ducts larger than 1220 mm, multiple frame chapters shall be used.

Blades shall not be less than 18 gauges. The duct shall be stiffened at the damper location. Volume dampers for circular ducts shall be of the multiple opposed blade type fitted in a square chapter.

The Contractor shall supply and install volume control dampers at least 3 duct widths away from each diffuser and where indicated on the drawings. Splitter dampers shall be installed at branch connections to main ducts regardless of whether they are shown on the drawings or not. Multi- blade damper shall be used when the width of the damper is over 1200 mm. Constructional details of dampers shall be as shown in the standard drawings attached and generally in accordance with SMACNA recommendation.

Volume control dampers shall be of the opposed blade multi-leaf type except for ducts less than 300 mm in height where single-leaf dampers may be used.

Motor operated dampers shall have suitable connecting rod and base plate for mounting the damper motor. Motor operated dampers in the "close" position shall not permit air leakage in excess of 2% of the design air quantity.

Damper blades shall be constructed of not less than 16-gauge galvanized sheet in two halves streamlined around spindles. Spindles shall be not less than 9.5 mm bright steel bar and shall rotate in bronze or nylon bushes at both ends. Spindles shall have a slot at each end to indicate damper position. All dampers shall be constructed to ensure air-tight closure of the blades when in the closed position. Damper blades shall be provided with control linkages to provide for opposed blade operation. For volume control, and fitted with stainless steel soft seals fitted to blade edges and between blade ends & casing low leakage where features are called for.

All dampers shall be capable of performing their service without causing vibration or noise. Splitter dampers shall be provided with fully adjustable locking quadrants with the "open", "normal", and "closed" positions clearly marked.

Manually operated damper shall be provided with adjustable locking quadrant of approved manufacture. After balancing has been satisfactorily completed, the position of each damper lever is to be locked. The vapor seal on the ductwork shall be suitably protected by 16g galvanized steel plate to avoid damage by an adjustable quadrant in the immediate vicinity of the locking quadrant.

All normal dampers shall have a leakage at closed position of less than 2% at the pressure specified, except low leakage damper, when specified.

Fire Damper

Each fire damper shall have a fire protection rating of 1.5-hour and a 74°C fusible link. Fire damper frame shall be constructed of 20-gauge galvanized steel channel. Blades shall be curtain type of 24-gauge galvanized steel and finish shall be mill galvanized to ASTM A653-99 G90.

Each fire damper shall be constructed and tested in accordance with UL Safety Standard 555.

Fire dampers shall be equipped for vertical or horizontal installation. Horizontal mounted dampers shall be spring loaded.

All necessary accessories such as sleeves, angles, etc. shall be provided for proper installation of fire damper as per manufacturer instructions.

Smoke Damper

Dampers shall be suitable for use in dynamic or static smoke control system. Damper frame shall be constructed of 16-gauge galvanized steel hat channel with mitered corners reinforced with die- formed corner gussets for strength. Blades shall be extruded aluminum airfoil design on maximum 152 mm centers with an integral structural reinforcing tube running the full length of each blade. Blade axles shall be 12.7 mm Dia. Plated steel, double bolted at each end of the blade provides a positive locking connection. Bearings shall be self-lubricating type.

Blade linkage shall be zero-maintenance, concealed in frame, out of airstreams. Blade seals shall be silicone, mechanically locked in extruded blade slots. Adhesive or clip-on type blade seals are not acceptable.

Dampers shall be tested and qualified to UL555S class II leakage rating to a minimum rated airflow of 10.0 m/s velocity with blades fully open at a rated static pressure differential of 1 kPa with blades fully closed.

The electrical actuator shall be factory installed by the damper manufacturer and shall have been tested and classified together under UL555S, at an elevated temperature of

121oC. Actuators shall incorporate an internal spring return mechanism. (External is not acceptable).

3.15.7 Cleaning and Blowing Out

All ducts shall be internally cleaned before running the fans. Suitable metal/PIR covers shall be provided at all times during installation to prevent the ingress of foreign materials. As soon as practicable and before final finishes are completed, the main fans shall start to blow out dust which may collect in the ductwork before connecting to terminal units. Care must be taken that no discolouring of the ceiling takes place, or other equipment is disturbed due to inadequate protection to keep out dust and dirt. Timing of this work shall be observed to ensure that minimum inconvenience is caused to the works of others.

3.15.8 Ductwork Testing

Low-Pressure Ductwork Testing

One-inch diameter holes in low-pressure ductwork shall be used for checking air quantities. Low-pressure duct shall be leak tested, before insulation is applied, by capping temporarily all tee-offs and openings and turning on the main fan or air handling unit associated with the duct, and joints manually inspected and leaks manually checked to the satisfaction of the Consulting Engineer, making use of the zero-flow head of the fan. This pressure should not, however, exceed 500 Pa during testing.

4.16 Exhaust Fans

4.16.1 General

All fans shall be prepared to withstand the corrosion protection way. Relevant prices shall be addressed in the quoted bill of quantities.

Fans that will be installed as roof top mounted, shall be weatherproof type fans it shall be capable to fix the roof slab strongly. All fans shall be installed by using suitable vibration isolators to the roof slab to mitigate the vibration transfer through the structural elements. The contractor shall take all precautions to avoid the transfer vibration inside the building when installing roof mounted fans.

Fans shall be carefully selected and be entirely suitable for their particular service, position of fittings and chosen with respect to corrosion, in flammability or other hazardous application.

The fans shall be capable of handling the air quantity necessary for the specified system performance against the resistance of the system. The resistance shown on the schedules are for tendering purposes only and the contractor shall be held responsible for

checking the final system resistance before ordering the equipment.

Fans shall be balanced and free from vibration. All fans shall have complete impeller assemblies including drive components, and statically and dynamically balanced.

Equipment Displacements as measured on equipment: (mm)

Ventilation Fans and Fan Coil Units

(Centrifugal & Axial)

Under 600 rpm	0.1
600-1000 rpm	0.075
1000-2000 rpm	0.05
Over 2000 rpm (impeller speed)	0.025

Performance test of up to 100% normal running speed shall be conducted. The rotor and pulley shall be further balanced on site to the approval of the Engineer. The rotors shall be selected for “QUIET” operation in accordance with the relevant British Standard Code.

Unless otherwise specified, fans shall be designed and constructed for continuous operation.

All fans shall be fitted with engraved identification and directional labels giving full details of speed, h.p. pulley and belt sizes and type of grease required and mechanically fixed where they can be easily seen and not subject to potential damage.

After manufacture, the casing, impeller shaft and belt guards shall be thoroughly cleaned and given two coats of “Anodise” anti-corrosive paint or other approved treatment.

Centrifugal Fans

Centrifugal fans shall be supplied and fitted generally as shown on the accompanying drawings. Unless otherwise specified or shown on the Drawings, the centrifugal fans shall be double width, double inlet type and fans handling more than 35,000 CMH shall be of galvanised steel or approved equivalent. All centrifugal fans shall be belt driven unless otherwise noted on the Schedule.

All vee-belt drives and shafts shall be fitted with easily removable expanded and flattened steel guard of 6mm mesh size and mounted on 14 SWG angle steel frameworks. All guards shall have access openings to the shaft ends to enable tachometer reading to be taken.

All belt drives shall have approved lock pulleys on both the driver and driven. Belts sets shall be matched. Belts which have taken a permanent set through remaining idle shall

be rejected. All belt speed shall not exceed 23m/sec.

Motor speed and fan speed shall not exceed 1500 rpm.

The main vibration isolators shall be metal springs, fitted with ribbed neoprene pads not less than 8mm thick at the top and bottom of the spring. The ratio of the spring height to spring width shall be approximately equal when the spring is deflected under load. Mounting shall be located high enough or spaced far enough apart to prevent the machine rocking excessively. Mounting shall be easily visible and accessible for inspection and maintenance. When the mountings are carrying the static load, there shall be a clearance of not less than 20mm under the base. Notwithstanding the above, isolation shall be in accordance with the Schedule of Vibration Isolation Equipment.

In the loaded condition, the spring shall be able to sustain a further 50% increase in load before the spring bottom; in this condition it shall not exceed the elastic limit of the spring. All springs shall be constructed of best quality steel, properly heat treated.

Isolators shall be Power sob SL or approved equivalent.

All isolators shall be sized to have the following static deflection when loaded unless otherwise stated in the Schedules and/or Drawings: -

<u>Operating Speed</u>	<u>Deflection</u>
1,000 rpm and above	25 mm
500 rpm - 1,000 rpm	40 mm
400 rpm - 500 rpm	50 mm

Axial Fans

Axial fans shall be supplied and fitted generally as shown on the accompanying drawings. The fans shall be selected with direct driven motors giving non-overloading characteristics. Motor speeds shall not exceed 1500 rpm, or as noted on the schedules.

Casings shall be of standard length designed to protect both the motor and impeller, continuously welded throughout and hot-dipped galvanised after manufacture. Inspection doors to enable direction of rotation to be checked shall be provided.

Terminal boxes welded to the casing shall be provided for electrical connection to fan motor. Lubrication of bearing shall be possible from outside the fan casing.

Impellers may be of glass reinforced polyester resin or die cast

aluminium. Flanged connection to ductwork shall be made with

cadmium-plated bolts. Industrial-Type Propeller Fans

Propeller-type ventilation fans manufactured from heavy gauge metal or other approved materials designed for industrial or commercial uses and capable of continuous operation shall be supplied and fitted generally as shown on the accompanying drawing. Fans shall be ring-mounted or diaphragm-mounted to suit the particular installation; diaphragm-mounted type shall be used for in-duct application. Where fans are fitted in a run of ductwork, extended lubricators shall be provided in sympathy with a suitable size access panel in the ductwork.

Fan speed shall not exceed 1,000 rpm unless specifically approved by the Engineer in writing. Bearing shall preferably be of the sleeve type, and the fans shall be completed with resilient mountings, internal rings or wire guards. External grilles and fans chambers shall be provided as shown on the accompanying drawings.

Fans shall be directly coupled to totally enclosed squirrel cage

motors. Inline Fans

In-line duct fans shall have non-overloading characteristics to suit the performance duty specified. In-line duct fans shall be of direct driven type.

The fan blades shall be aerodynamically designed, backward-curved, constructed of aluminium plate and combining the impeller with the rotor of the external-rotor motor. Motors and impeller shall be factory matched and statically and dynamically balanced.

Motors shall be suitable for operating in atmosphere of up to 95% and up to 40 deg. C. The fan housing or casing shall be constructed in heavy gauge (1.4 mm minimum) mild steel with paint finish or epoxy powder coating and stored dried, and flanged at both ends for bolting direct to connection ductwork.

Bifurcated Fans

The impeller shall be coupled directly to cage induction totally enclosed motor which is fitted inside a separate compartment and thus out of the airstream.

Motors shall be of the totally enclosed cage-induction design with insulation class to 'F' specification and ratings complying with BS5000 Part 99 and IEC34-1. Where indicated, two-speed motors shall be provided. For motor ratings above 0.37kW, three phase motors shall be provided unless otherwise indicated. Single phase motors shall be of the capacitor start-and-run type, having a power factor generally above 0.85.

Fan shall be suitable for continuous operation at temperatures up to 250deg. C. Maintenance instructions indicating the type and quantity of high temperatures applicable to each installation shall be furnished.

The fan unit when horizontally mounted shall have the motor compartment inlet and

outlet at the position of 3 o'clock or 9 o'clock or vertical downward. The casing and external terminal box shall be hot dip galvanised.

Duct work

All ductwork under this section shall be as per specification in section above.

4.16.2 Wall Mounted Exhaust Fan

The Exhaust fans shall be walling mounted type with fan casing and impeller manufactured from plastic and the front grille made to have good toughness. The motor shall have splash proof protection and class 2 insulation. Neon light indicator shall be provided on the face grille for identification of running condition. The motor index of protection shall be IP65, and motor insulation class shall be of class F. The electric motor shall be fitted with an internal thermal protection device to protect against abnormal overheating. All wall mounted fans shall be completed with back draft shutters to enclose the ventilated spaces during the idle time.

4.16.3 Duct Mounted (**Acoustic Cabinet type**) Exhaust Fan

The In-Line duct centrifugal duct fans shall be ducted mounted and acoustic cabinet type with fan casing and impeller manufactured from plastic and the front grille made to have good toughness. The motor shall have splash proof protection and class 2 insulation. Neon light indicator shall be provided on the face grille for identification of running condition. The motor index of protection shall be IP65 and motor insulation class shall be of class F.

4.17 Vibration & Noise

The vibration and noise control of the equipment installed is of prime importance. The Contractor shall pay special attention to the problem of vibration and noise and is required to guarantee that the installation will not generate vibration or noise of the intensity to exceed the specified limits or cause annoyance to the patients/occupants in the building.

Equipment, FCUs, Diffusers, Ducts, Exhaust Fans etc. shall be selected to maintain the required sound pressure level inside the conditioned spaces.

The contractor shall submit a test certificate to verify the stipulated sound pressure level in the catalogues with respect of the above equipment.

If required, isolating hangers, supports and metal sleeve with mineral fiber packing (passing through walls) shall be provided for all piping and ducting system installed at all

levels to prevent the structural born vibration and air born vibrations transfer to the occupant area.

4.18 Acoustic Treatment

Acoustic lining to be greater than or equal to 25mm thick elastomeric open cell nitrile rubber insulation of 40-70 kg/m³ density with thermal conductivity is not exceeding 0.04 W/mK, dust and fibre free, Class 0 type as per the BS 476-part 6/7. Coefficient of Sound Absorption (NRC) shall be maintained at 0.6-0.85 range.

Acoustic lining to be installed in the discharge duct of each supply air fan at least 6 m beyond the fan discharge, in the intake duct of each return or exhaust fan, at least 6 m beyond the intake plenum to and including the intake plenum and in the discharge duct of each fan coil unit. Linings shall not be installed for the kitchen hood exhaust ducts.

Prefabricated sound traps to be used where unusual noise problems are encountered and in high pressure duct systems.

Additional acoustic treatment is to be provided as required by the acoustic consultant.

4.19 Power Supply and Electrical work

All electrical work shall be carried out in accordance with IEE regulations 17th Edition or later. General

The Contractor shall supply and install the electrical equipment and services necessary for the efficient safe and satisfactory operation of the plant and systems detailed elsewhere in the specification, including: -

- All motors, starters, circuit breakers and/or isolating switches and switch fuses.
- All control panels complete with circuit breakers, switches, remote push buttons and indicator lights.
- All control equipment, control cabling and associated conduit work.
- Conduit, cable tray, cabling and control wiring between the control panels, alarm panels, and the various items of equipment.

The whole of the work shall be carried out in accordance with this Specification the drawings accompanying this Specification, and to comply with the requirements of the local Authorities and to Engineer's satisfaction.

Control Panels

Each control panel shall be self-contained, wall mounting, or floor mounting, metal clad, cubicle type with flush hinged doors for front access. Doors shall be provided with car type likeable handles.

Control panels shall generally be constructed, fitted and tested as specified for the 'Control Panels'. The fault rating of the panel shall not be less than the prospective fault level available through a short circuit at the panel itself.

Control panels for outdoor installation shall be suitably weatherproofed and with cable boxes installed within the control panels all to the approval of the Engineer.

Moulded Case Circuit Breakers (MCCB)

Moulded case circuit breakers shall comply fully with B.S. 3871: Part 2 and case shall be of moulded insulating material of good mechanical strength and non-tracking properties. The tripping mechanism shall be calibrated in compliance with British Standards at the factory and the breakers shall be sealed to prevent tampering. The MCCB shall be of type 3.

Moulded case circuit breakers shall be of manual or automatic operation as required. The automatic type shall each incorporate a trip unit to provide overload and short circuit protection.

The trip unit for each pole shall provide inverse time delay under overload conditions and instantaneous magnetic tripping for short circuit protection.

The M.C.C.B. shall be so designed that when on tripped condition, the circuit breaker cannot be switched on again unless it has been reset by switching to OFF position first. The operating conditions (i.e. ON, OFF or TRIP) of the circuit breaker shall be clearly indicated.

Moulded case circuit breakers shall be Single Pole and Neutral (S.P.N.) or Triple Pole and Neutral (T.P.N) Type as required. The construction and operation of the circuit breakers shall be such that if a fault occurs, all the poles of the circuit breakers shall operate simultaneously to isolate and clear the fault efficiently and safely without any possible risk to the operator or to the installation. Each circuit breaker shall incorporate trip-free mechanism to ensure that the breaker cannot be held closed in fault conditions. The operating mechanism of the circuit breakers shall be hermetically sealed at the factory and all metallic parts associated with the operating mechanism shall be treated against rust and corrosion. The short-circuit breaking capacity of the M.C.C.B. shall not be less than the maximum prospective fault levels at the point where the M.C.C.B. is installed.

The Contractor shall be responsible to select and provide the correct type of circuit breakers for protection of the appropriate type of circuit. The Contractor shall also be responsible to ensure that the type of fused used shall co-ordinate with the type of circuit breakers offered to give good and proper protection and discrimination of the electrical system.

Moulded case circuit breakers can be used in locations where the short-circuit current exceeds the breaker's established interrupting ratings provided suitable current limiting fuses are incorporated in the breakers. The ratings of the breaker and fuse must be carefully selected to prevent damage to the breaker to ensure co-ordination and to secure the high short-circuit protection required. The Contractor must provide the relevant data for formal approval by Engineer before the use of integrally fused M.C.C.B.

Service Contactors

Contactors shall comply with B.S. 5424 with uninterrupted ratings (U.R.), mechanical duty Class II and making and breaking category A4.

Contacts shall be renewable butt type, solid copper hard silver faced, fully shrouded main and auxiliary contacts and the design shall be such as to ensure effective freedom from contact bounce and sticking of the fixed and moving portions of the magnet assembly. Auxiliary contacts shall be provided as required by the Specification and/or Drawings.

Contactor coils shall be fully tropicalised and wound for continuous operation at phase voltage with Class 'E' insulation to B.S. 2757.

Magnet shall be fabricated from silicon alloy riveted electrical steel sheet with shaded pole and magnet/armature assemblies shall be fully floating and self-aligning.

Arc chutes and magnetic blow out coils shall be fitted to the larger sizes as necessary.

Meters and Relays

Meters and relays for external panel mounting shall be of the flush pattern, with square escutcheon plates finished matt black and pressed steel cases. Indicating instruments shall be to B.S. 89 1st grade, moving iron spring controlled with 100 mm diameter dials (240-degree scale) with external zero adjustment, integrating meters shall be to B.S. 37 Parts 1 and 2 and Part 4 with cyclometer registers and protective relays to B.S. 142.

All the measuring meters shall be calibrated by the relevant local testing authority before installation; test certificates from the relevant authority on the calibration shall be available when requested by the Engineer. All cost associated with the calibration by local authority shall be deemed to be included in the Contract.

Relays are to be approved types complying with B.S. 142 or equal and shall have approved characteristics and be flush mounted in dust proof cases. Relay cases shall generally be finished in black enamel.

Relays shall be of approved construction and shall be arranged so that adjustments, testing and replacements can be effectuated with the minimum of time and labour. Relays of the hand reset type shall be capable of being reset without opening the case.

Electricity reset tripping relays shall be provided where necessitated by the system of control. Relay contacts shall be suitable for making and breaking the maximum currents which, they may be required to control in normal service but where the contacts of the protective relays are unable to deal directly with the tripping currents, approved auxiliary contactors, relays; or auxiliary switches shall be provided. Separate contacts shall be provided for alarm and tripping functions. Relay contacts shall make firmly without bounce and the whole of the relay mechanisms shall be as far as possible unaffected by vibration or external magnetic fields.

Relays, where appropriate shall be provided with flag indicators of approved type, phase coloured where applicable. Flag indicators shall be of the hand reset pattern and shall be capable of being reset without opening the case. Where two or more phase elements are included in one case separate indicators shall be provided for each element.

Relays with provision for manual operation from outside the case, other than resetting, will not be accepted, and time delay relays shall not be of the dashpot type.

Relays, whether mounted on panels or not, shall be provided with clearly inscribed labels describing their application and rating in addition to the general-purpose labels.

Approved means shall be provided on the relay panels for the testing of protective relays and associated circuits, withdraw able type cases and plug-in type test facilities being preferred.

Attention is particularly drawn to the humid tropical climate, and relay designs should be entirely suitable for duty under these conditions.

To minimise the effect of electrolysis, relay coils operating on D.C. shall be so connected that the coils are not continuously energised from the positive pole of the battery.

Instruments, meters and relays located on the front of the switchboards shall be so positioned that as far as possible, each instrument, meter and relay is adjacent to the unit with which it is associated. Other relays more suitable for mounting inside the cubicle such as those required for back indication and tripping etc., shall be grouped conveniently in dust proof cases with removable covers to provide easy access for cleaning and adjustment without dismantling. All relays shall be heavy duty pattern, unaffected by external vibration and capable of operation in any position. Meter panels shall be hinged to provide ready access to connections, and small wiring shall be enclosed in flexible plastic conduit. All meters and relays shall be fully tropicalized. All terminals shall be completely insulated and potential circuits shall be suitably fused.

Delay timer relays (1sec - 10sec) shall be provided to prevent simultaneous starting of equipment's that may cause tripping of power supply to the equipment.

Indicating Lamps

Indicating lamps shall be the type with built-in transformer and made of brass with chromium plated bezel and locking ring. The lamps shall be adequately ventilated and easily removed or replaced from the front of the panel without the use of extractors. Lamps shall be clear and fit into an accepted standard form of lamp holder.

The colour in coloured lamp glasses shall be in the glass and not an applied coating. Transparent synthetic materials may, however, be used instead of glass, provided no material flow or discolouration takes place due to heat from lamps.

Fuses

Cartridge fuses complete with carriers for protection of auxiliary circuits shall be provided. Fuses shall be of the H.R.C. type category 400/AC 4 class Q to B.S. 88.

Motors

All motors of 1 H.P. and above shall be wound for 400-volt 3 phase 50 Hz supply. Motors of less than 1 H.P. may be wound for 230-volt 1 phase 50 Hz supply. Motors shall be of the totally-enclosed type with fan cooling. Adequate precautions shall be taken to prevent the ingress of moisture.

All motors shall be in accordance with B.S. 2613 and B.S. 2757, of squirrel-cage type,

with Class 'E' insulation to B.S. 2757. Motors shall be continuously rated (C.M.R. category of B.S. 2613) and shall have torque characteristics as required by their respective duties.

Bearings shall be of ball or roller or sleeve type as applicable.

Terminal boxes shall be provided suitable for reception of the MICC cables, PVC armoured cables, XLPE cables or screwed conduits entry as required.

All motors shall be adequately earthed to meet the requirements of the local electricity supply authorities.

For all standby equipment, motors shall be equipped with heaters. The heaters shall be connected up to ensure that when the motor is on, the heater is switched off and vice versa.

Motor Starters

Motor starters shall be constructed for intermittent duty in accordance with B.S. 587 and equipped with over-load, single-phasing and under-voltage protection. Where remote control is required, starters shall be of Contractor type with coils wound for 230-volt 50 cycle operation. All motor starters shall be suitable for mounting in the main control panel and all starter cubicles shall be fitted with thermostatically controlled heaters to maintain the temperature within the cubicle above dew point. Heaters shall generally be located in the bottom of the cubicle, with the thermostat at the top.

The heater terminals at the motor and starter shall be clearly labelled: -

“CAUTION - MOTOR HEATER - ALIVE WHEN MOTOR STOPPED”

Starters shall be of the following types unless otherwise indicated on the Specification Drawings: -

- Up to 2.2 kW motors - Direct-on-line.
- Above 2.2 kW up to 15 kW motors - star delta close transition type.
- Above 15 kW - auto-transformer close transition type.
- Starting current for DOL starting shall be limited to 6 (six) times the full load current.

For Star-Delta starting, the starting current shall not exceed 3 (three) times the full load current. Auto-transformer starters shall limit the motor starting current to 2.5 times the normal full-load current.

Both star/delta and auto-transformer starters shall be of the close transition types. The auto-transformer starters shall be provided with trappings suitable for connection to 40% - 75% of line voltage in step of 5%. All motor starters shall be tested to B.S. 587.

All starters shall be automatic type complete with “Start”/“Stop” push-buttons, auxiliary contacts as required, MANUAL/OFF/AUTO selector switch and provision for remote controls as required. All motors shall be connected through suitable MCCB in addition to starters.

The Contractor shall submit the starting characteristics curves of all motors as well as relevant test certificates from a recognised testing authority for the auto-transformer starters to the Architect/Engineer for approval.

Motor Isolators

The supply to each motor shall be controlled by means of an efficient cut-off switch placed in such a position as to be easily handled by the person in charge of the motor, and connected such that the power supply can be cut off from the motor and from the regulating switch, remittances or other devices connected to it.

Motors arranged for remote control shall be provided with a similar cut-off switch placed in such a position as to be easily handled by the person in charge of the motor, and connected such that the power supply can be cut off from the motor and from the regulating switch, remittances or other devices connected to it.

Wiring System

Unless otherwise stated or shown on the Drawings, all wiring systems shall be carried out in PVC insulated cables draw in into galvanised steel conduits or trunking; conduits shall be concealed in structure or concealed above false ceiling, except in plant rooms where exposed conduits are permitted.

Cables from the A/C MCC board to serve the outdoor equipment shall be draw in into galvanised steel trunking, casted within the outdoor a/c plant RC base.

All cables shall be of size capable of carrying the maximum current without exceeding 2.5% of nominal voltage drop from consumers terminals to any point in the installation under normal conditions of service in accordance with the 14th Edition of the I.E.E. Regulations for the Electrical Equipment of Buildings, and no cable smaller than 2.5 sq. mm shall be used for power sub-circuits.

All cables shall be carried in conduit, on cable trays or in cable trunking where applicable and no joints will be permitted.

The number of cables carried in each conduit shall not in any circumstances exceed that defined in Table B5 CP5:1977 of the I.E.E. Regulations for the Electrical Equipment of Buildings.

PVC Cables

PVC cables for sub-mains and sub-circuits shall be of 600/1000-volt grade comprising high conductivity stranded copper conductors of the sizes shown on the drawings, to B.S. 6360, PVC insulated to B.S. 6004 and 6346 as applicable. Cables drawn into non-metallic pipe ducts or fixed to cable trays shall be PVC sheathed. Insulation colours shall be in accordance with Table B.4 CP5:1977 of the I.E.E. Regulations for the Electrical Equipment of Buildings.

Fire Resistant Cables

All outgoing cables from control panels to mechanical fans serving protected corridors, lobbies and staircases shall be fire-resistant cables to IEC 331 requirement.

Fire resistant cables of 600/1000 volts grade to IEC/331 requirements or equivalent shall be used for emergency lighting and exit sign circuits as well.

The cables shall be adequately protected from mechanical stress and damage. The cables shall be run in conduit if there is no protection jacket surround the cables, otherwise they shall be run in trunking or as directed by the S.O.

The installation of the cables shall be in accordance with the manufacturer's recommendation. All joints and accessories shall be of the manufacturer's standard products.

Test certificates from the PSB or other reputable testing authorities showing the performance of the cable and evidence of compliance with the relevant standards shall be submitted to the S.O. prior to installation.

Erection of Cables

Erection of cables shall include the following:

- All measuring, marking off and cutting to length.
- Temporary sealing of cable ends when necessary and testing of cut ends prior to connection.
- Supply, delivery and erection of all racks, clamps, saddles, trays, supports, bushes and other items required for erection and fixing of cables, including excavation where necessary.
- Design, provision, erection and painting of all additional supporting steelwork.
- Sheath bonding in the case of single core cables including supply of necessary materials.
- Forming of necessary bends, surface fixing at intervals as specified herein.
- Sealing of cables in pipes or ducts.
- Tests at site on completion including continuity, phasing out and

insulation resistance between conductors and between conductors and sheath employing a 500 volt 'Megger' tester or other approved type.

Unit rates quoted for erection of cables shall include the above

works. Jointing

The Contractor is to be wholly responsible for the sealing and jointing of all cables erected and jointed under this Sub-contract.

Cable sealing and jointing is to be in accordance with the best current practice and of first-class workmanship. Where cable sheaths are used as earth continuity conductors, glands are to have the necessary contact surfaces or stamps to provide a low resistance path under fault conditions. The cost of all jointing materials for the termination of cables into sealing boxes attached to equipment supplied under other Contracts is to be included in the prices for jointing into these boxes.

A record is to be kept of all joints and terminations made and is to include the name of the joiner and mate, the date of making, the date of testing and the weather conditions prevailing. Three copies of this record signed by the Contractor are to be supplied to the Engineer.

Straight Joints

Straight joints in any of the cables installed under this Contract will only be permitted in very Exceptional circumstances and only with the Engineer's approval in writing. The cost of such straight joints, if permitted by the Engineer, shall be borne by the Contractor unless such joints are arising from unavoidable limitations in manufacturing lengths or from alterations in routes after initial approval.

Labels

All cables shall be identified by lead labels with 5mm high min. stamped cyphers securely wired on to the tinned copper wire.

Installation Materials

All wiring, conduit, conduit boxes, cable trunking and brackets necessary for the complete installation shall be supplied and installed under this Contract. The Contractor's attention is drawn particularly to the building construction as this affects materially the length of conduit runs.

Cable Trunking

Cable trunkings shall be employed as indicated in the Specification drawings.

Trunking shall be manufactured from good quality hot dipped galvanised mild sheet steel of not less than 1.25 mm thickness (18 SWG) for sizes up to 100 mm by 100 mm and not less than 1.60mm thickness (16 SWG) for sizes up to 150mm by 150mm and not less than 2.00 mm thickness (14 SWG) for larger sizes.

The trunking shall be complete as required with proprietary made bolted flanged outlets, blank ends, reducers, outlet bushes, bends, tees, sleeve couplings, intersection four-way boxes and fittings adaptors. Bridge pieces to act as cable retainers shall be readily removable, but positive fixing by machine screws for the cover shall be provided. The inner radius of any bend shall not be less than 2 ½ times the minor dimension of rectangular section trunking. A 25 mm x 3 mm copper tape shall run throughout the whole length of trunking to provide earth continuity. The copper shall be bonded at intervals to the trunking itself and also to any other metal which requires to be earthed.

Trunking shall be supported adequately by suitable brackets fabricated from galvanised mild steel flat.

Vertical runs of trunking which pass through floors must be provided with fire barriers inside the trunkings, these barriers should consist of a non-inflammable material cut away to enable the cables to pass through.

Trunking runs shall be erected complete before any cable is drawn in and the number of cables installed shall be such that a space factor of 45% is not exceeded.

The trunkings shall be painted with two finishing coats of good quality orange paint or any other colour paints to be advised later by the Engineer.

Conduit Installation

All conduit, fitting and accessories shall be galvanised and shall comply with B.S. 4568. Conduit shall be screwed and welded Class 'B' and fittings shall be manufactured from steel or malleable cast iron. Conduits shall be concealed in walls column and floors or run on the surface, as shown on the specification drawings.

Concealed conduits shall be fixed securely to prevent movement before casting of floor slabs, floating of plaster and casting of columns and beams.

All conduit and accessories shall be painted with one coat of red lead wherever the exposed galvanised surface has been cut or otherwise damaged including exposed threads and connections after erection.

Conduits shall be properly and tightly screwed into the full depth of box spouts and butted in sockets between lengths to ensure maximum mechanical strength and electrical

continuity so that the wiring is continuously and effectively protected throughout its whole length, and is not in any way under mechanical stress.

The whole of the conduit system shall be electrically continuous throughout and in addition a separate earth continuity conductor shall be provided in all metal conduits. Further, all conduits shall be earthed at terminations.

Flexible metal conduit shall not be used as the sole means of providing earth continuity, and a separate earth-continuity conductors complying with the appropriate requirements of the current Edition of the I.E.E. Regulations for the Electrical Equipment of Buildings shall be provided for every part of a system formed by such conduit.

Conduit sizes shall be selected carefully for the number and sizes of cables they are to contain and conduit shall be arranged with an adequate number of boxes, accessible for the life of the installation so as to allow easy draw in or draw out of anyone or all of the cables at any time and shall not in any circumstances be less than 20mm and cables drawn in shall not be greater than the appropriate number permitted in Table B5 of the current Edition of the I.E.E. Regulations for the Electrical Equipment of Buildings.

Cables for medium voltage circuits shall not be drawn into the same conduit for extra low voltage systems.

Where condensation likely to occur in surface conduits they shall be laid with falls so as to drain off condensed moisture without entry into terminations. Provisions shall be made where necessary for leading the drainage away from outside walls, ceilings, fittings and accessory boxes and collecting spots and small-bore tubing may be used for this purpose.

The inside surface of all conduits and fittings used in connection therewith shall be smooth and free from signs of corrosion, burrs and all other defects. The ends of conduits shall be cut square, filled and remerged out after and care shall be taken to ensure removal of cutting oil and sward.

All corners shall be turned by easy bends or sets made cold on bending machines without deformation of the section of the conduit or opening of seams and the inner radius of any bend shall not be less than $2\frac{1}{2}$ times the outside diameter of the conduit. Where it is un-practicable to set the conduit, normal or half normal bends may be permitted but in no circumstances shall solid or inspection elbows or 'tee' pieces be used.

When conduits terminate at a metal base, distribution board, adaptable box, motor starter, terminal box or other fitting not provided with screwed E.T. conduit entry a socket shall be screwed to the end of the conduit and a smooth bore male brass bush screwed into the socket entered from inside the metal case which shall be drilled with a clearance hole for the bush. The end of the conduit should be together with the bush

after the bush has been pulled up tightly against the inside of the case.

Conduit terminations to apparatus subject to vibration or movement shall be made off in flexible metallic conduit which shall be heavy gauge, weatherproof type P.V.C. sheathed overall, and sweated into heavy brass adaptors with a male thread of connection to the rigid conduit system at each end. Reliance shall not be placed upon the flexible tubing as an earth conductor and bare tinned copper wire of not less than 1.5 sq. mm shall be run inside and connected to the equipment earth terminal at one end and isolating switch earth terminal at the other end.

All boxes shall be fixed securely to walls, ceilings, etc., by means of at least two screws correctly spaced and all conduit runs shall be straight and run either horizontal or vertically; diagonal runs will not be permitted.

Conduit work and accessories where not concealed shall be fixed effectively by means of heavy pattern spacing saddles to hold off the conduit from the surface and approval metal or other non-- disintegrable plugs of proprietary manufacture shall be used for fixings.

On straight runs the conduit shall be supported by saddles at intervals not exceeding 900 mm in addition to supports provided by structure, box or fitting included in the run except that for 32 mm conduit and larger, saddles may be spaced at intervals of not more than 1200 mm apart.

Bends must in all cases be supported on each side by two saddles as near thereto as possible and a draw in box shall be provided after two bends and after not more than each 9 metres of straight run. All conduit runs shall be planned by the Contractor and shall be indicated or marked out on Site for the Engineer's approval before installation is commenced.

Where conduit is or may be in contact with steelwork of any description an efficient and permanent metallic bond shall be made between conduit and steelwork.

Where conduits cross expansion joints, they shall be installed so as not to resist relative movement of the sections.

Immediately on completion of erection of any conduit during building construction all exposed switch, conduit risers shall be plugged effectively against the ingress of water and dirt particularly where concrete will be poured. Such seals shall be maintained in good order for such time as is necessary to complete wiring and connection of fittings and switches.

On completion of erection the conduits will be inspected by the Engineer and may be tested at his discretion by ball or plug gauge before any wire is drawn in. All conduits shall be swabbed out and free from moisture to Engineer's satisfaction before wiring is

commenced; draw in tapes with absorbent cloth, such as Winceyette, flannel or army pull through cloth, shall be used for this purpose.

On completion of the installation all exposed conduits shall be painted with two coats of good quality orange paint or any other colour paints which may be advised later by the Engineer.

Safety equipment, notices, etc.

One set of the following equipment shall be supplied and installed with each of the control panels: -

- Solid rubber insulated mats complying with B.S. 921 in front of and extending the full length of all the Control Panels.
- One all insulated hand-lamp with guard and shield complying with B.S. 1980 complete with lamp, 10 metres length heavy duty PVC/PVC flexible and unbreakable 13A plug (MK.665/3).
- One battery operated hand-lamp with flat base and carrying handle, complete with lantern type battery, bulb and spare bulb.
- Copies of all statutory safety notices, regulations and instructions for resuscitation and treatment after electric shock; all surface treated with clear varnish, in suitable wall mounted frames.
- A varnished and mounted on suitable hard backing and framed in glass panel copy of the schematic diagram of the air-conditioning electrical single line diagram as supplied and installed bearing all necessary information for maintenance and operation, as approved by the Engineer

4.20 General

As the Employer has a prime concern about the energy savings in the complex during operations, the tenderer is advised to propose any kind of Energy Saving methods together with a Value Engineering proposal applicable to the proposed MVAC system. The energy saving / value engineering proposal should include a comprehensive report with necessary calculations indicating total cost savings for three years period.

4.21 Quotation

The quotation shall be for supply, installation and commissioning of all equipment. Provision also must be made in the offer to prepare and submit 'As Built' drawings and commissioning reports.

Complete manufacturer's Catalogues and Technical Data with respect to all equipment offered must be submitted with the offer. The following specific information must be

submitted for all equipment offered.

Make, Model No., Country of origin, Capacity details, Power consumption at design conditions, earliest delivery date.

A schematic layout of the proposed MVAC system indicating all energy saving proposals should be submitted with the offer. The total power requirement must also be given in the offer.

4.22 Factory Tests

Tenders should include the cost of the Witness of the Inspections of the Factory Performance Test of Two Consultants/Client Engineers.

The tender shall be submitted with a full proposal of the recommended training necessary for the owner's personnel to attend to routine testing, maintenance service and minor repairs including an indication of the duration of such training.

The number of people required to be trained shall be determined jointly by the Engineer and the Contractor.

The scope of training shall include on-site training and such training shall be prior to hand-over of the system. Technical training and system operation instructions to the owner's personnel shall also be provided during the commissioning and performance tests phases of the system.

System operation instructions shall be given by an experienced and competent representative of the Contractor who is thoroughly conversant with the air conditioning system installed.

4.23 Site Testing and Commissioning

The tender shall be submitted with the tender, a complete proposal with time schedule for testing and commissioning of the air conditioning & ventilation system. The program shall include a trial operation of all main equipment with any necessary adjustments to ensure that the system is working correctly. The Contractor shall provide all instruments and equipment together with commissioning engineers and adequate assistance for carrying out the commissioning and testing activity which shall be done in accordance with the recommendations of relevant Standards. If any portion of the works fails to pass the tests, the Contractor shall, at his own expense, carry out such alterations or replacements as are required to the satisfaction of the Engineer. The Contractor shall provide commissioning spares at his own expense.

Spare parts earmarked for maintenance shall not be used during this period.

4.24 Guarantee for the Mechanical/electrical Equipment's

All parts of equipment which, up to the end of Defects Liability Period, shall have

become unserviceable or shall have their usefulness impaired by any cause such as defective design, inferior materials or bad workmanship, shall be repaired or replaced by the Contractor free of cost to the Owner.

The discovery of a defect of this nature shall immediately be communicated in writing to the Contractor. Replace parts shall become the Contractors property and must be returned to him by the Owner, on payment of the costs of such return, by the Contractor to the Owner.

If the Contractor has failed to remedy the defects and affect the repairs or replacements within a reasonable period of time, then the Owner shall be entitled to repair or replace such items and claim from the Contractor the expenses actually incurred thereby.

Furthermore, the Contractor shall perform, at his own expense, all necessary tests and adjustments to the system in order to achieve the specified performance under the conditions as stated in the detailed specifications.

During the guarantee period, the Consultant has the right to claim again for the full guarantee period for parts which have been replaced as a result of the above-mentioned defects.

4.25 Operation and Maintenance Manual

The contractors shall submit catalogues, specifications of all equipment/materials. The Contractor shall submit 2 hard copies of Operation & maintenance Manuals which shall contain Product literature, specific operating instruction and maintenance instructions.

The Engineer has the right to decide the adequacy of information submitted by the contractor and request further information as necessary if required.

4.26 Maintenance Contract

Tenderer shall submit the terms and charges for service and maintenance contract after 12 months warranty period along with the tender.

LIST OF RECOMMENDED MANUFACTURES – MVAC WORKS

	Item	Manufacturer/Brand Name	Country of Origin / Country of Manufacturing
1.	VRV/VRF System (Including all indoor units – FCU & AHU)	Carrier McQuay York Trane Daikin Mitsubishi LG OR EQUIVALENT	USA/ USA, China USA/ USA, China USA/ USA, China USA/ USA, China Japan / Japan, Thailand Japan / Japan, Thailand Korea/Korea
2.	Inverter Split AC System	Carrier McQuay York Trane Daikin Mitsubishi LG OR EQUIVALENT	USA/ USA, China USA/ USA, China USA/ USA, China USA/ USA, China Japan / Japan, Thailand Japan / Japan, Thailand Korea/Korea
3.	Air Terminal Units	Betec CAD. Air Master Trox Beta OR EQUIVALENT	UAE, Europe
4.	Exhaust / Fresh Air Fan	S & P Fantech Greenheak Sisteven Dynair OR EQUIVALENT	Spain Australia Canada UAE
5.	Control Equipment	Honeywell Siemens Delta Control OR EQUIVALENT	USA USA Canada
6.	Sensors and Actuators	Honeywell Siemens Johnson Controllers Distech Control OR EQUIVALENT	USA USA USA Canada
7.	MCBs, RCCBs, MCCBs, Isolators	ABB Hager Siemens OR EQUIVALENT	Italy France Germany

8.	Coupling, Supports and Hangers	Diamond Grinnell Mupro Hilti OR EQUIVALENT	
9.	Insulation	Armaflex Aerofoam Insulflex K Flex OR EQUIVALENT	

Note:

The reference made here to certain manufacturers` products and items identified by registered trademarks, this has been done for the sole purpose of defining and establishing standards of quality and performance and not with the intention of restricting the procurement of materials or fittings to a particular manufacturer.

SERVICE AND MAINTENANCE AFTER FREE MAINTENANCE PERIOD

Annual fee for providing maintenance service.

The work shall include sending of Contractor's personnel once in every three months during normal working hours of a normal working day to inspect, clean, oil, grease, etc adjust the machinery and equipment and attending to emergency call back service immediately the owner notifies the contractor.

Bidder shall proceed, but not limited to the given check and test sequence of maintenance and service specified by the Bidding Document by authorized competent technical crew, once in every two months, during any day including holidays, as requested by the client.

The amount quoted for servicing and maintenance shall include the cost of supply of all replacement spares, necessary oil, grease and cleaning materials.

“Free Maintenance period (defects liability period) shall be 365 days from the date of formal handing over of Air Conditioning and Ventilation system to the Employer.”

Total per annum without VAT

(After free maintenance period)	1 st year	Rs.
	2 nd year	Rs.
	3 rd year	Rs.
	4 th year	Rs.
	5 th year	Rs.

The bidder shall supply a sample of his proposed service and maintenance contract document.

(Signature)

(Name)

SERVICE AND MAINTENANCE AFTER FREE MAINTENANCE PERIOD

Annual fee for providing comprehensive service.

The work shall include sending of Contractor's personnel once every two months during normal working hours of a normal working day to inspect, clean, oil, grease and adjust the machinery and equipment and attending to emergency call back service immediately the owner notifies the contractor.

Bidder shall proceed, but not limited to the given check and test sequence of maintenance and service specified by the Bidding Document by authorized competent technical crew, once in every two months, during any day including holidays, as requested by the client.

The amount quoted for servicing and maintenance shall include the cost of supply of all replacement spares, including compressors, condensers, evaporators, necessary refrigerant, oil, grease, etc.

“Free Maintenance period (defects liability period) shall be 365 days from the date of formal handing over of Air Conditioning and Ventilation system to the Employer.”

Total per annum without VAT

(After free maintenance period)	1 st year	Rs.
	2 nd year	Rs.
	3 rd year	Rs.
	4 th year	Rs.
	5 th year	Rs.

The bidder shall supply a sample of his proposed service and maintenance contract document.

(Signature)

(Name)

3. TECHNICAL SPECIFICATIONS OF FIRE SERVICES

3. General

The work covered in this section shall include, but not to be limited to all labor, materials, equipment and services required in connection with the Fire Protection System, Fire Detection System and related work as stipulated in the specifications, drawings and the equipment list for the proposed Central cold chain facility at Hulhumale.

The following services shall be provided in the premises complying with BS standards, requirements of Ministry of Defence and National Security of Maldives and requirements of Maldives National Defence Force (MNDF) as detailed in the drawings.

1. Supply and Installation of wet riser fire hydrant system complete with fire pumps, landing valves, hose reels, pipelines, fittings, fire cabinets etc. as per drawings and specifications.
2. Supply and Installation of portable fire extinguishers at the locations shown on drawings.
3. Design, supply and installation of Fire suppression system for Server room and HVAC control room in the building.
4. Supply and installation of addressable fire detection system complete with fire alarm control panel, smoke/ heat detectors, manual call points and exit sign boards as per drawings and specifications.
5. Contractor should obtain all approvals and compliance from the Fire Regulation Authorities (MNDF) before the commencement of installation, during and after completion of the installation.

The type of the system required for the building is decided based on the class of fire as per the classification given in latest edition of BS 5306 and requirements stipulated by MNDF. Since the building is a multi-storied building, the zoning system is identified. The design is in compliance with latest editions of BS 5306 and BS 5839. Further it is in line with the requirements stipulated by MNDF.

This specification shall be read in conjunction with all other parts of the Bidding documents and the accompanying drawings.

3.1 Preliminaries

The scope of work under this specification covers manufacture/ procurement, assembly, shop inspection & testing, shop painting, transportation of materials to site, storing, unloading

and transportation from store to site and handling at site, erection, testing, commissioning and performance guarantee tests of equipment and accessories of all fire services of the project.

The scope of work by the Contractor shall include but shall not be limited to the following:

To select, manufacture and supply the complete of all fire services and associated equipment specified under this technical specification.

Though its mention or nor all Brackets/Supports (internal & external) should be Hot dipped galvanized to the minimum of 65µm complying to the Class 4 requirements.

Supply of commissioning spares as may be required during erection, start up and initial operation of all the units/ systems till successful completion of commissioning. The price for commissioning spares should be deemed to be included in the contract price for the systems offered.

Supply of recommended spares for two years' normal operation of the total fire services with item-wise price breakup. The price for the two years' spares shall be deemed to be included in the contract price for the systems offered.

Supply of special tools & tackles required for maintenance of all fire services. Preparation and submission of a necessary load calculations, general arrangement drawings, design drawings, fabrication & erection drawings, as built drawings, drawings of fast wearing parts etc. Approval shall be taken on the load calculation, system layout drawings and equipment general arrangement drawings before start of erection of all the equipment and complete of total fire services system as per approved drawings and instructions of site engineer of customer / Owner/ Consultant.

Minor civil work like breaking of wall /floor /roof to make duct / pipe / cable passage and adjustment to civil foundations as required for erection and finishing and making good of the same after erection work including painting thereof. Fixing of anchor fastener on wall and ceiling for support is included.

Any other item /nature of work which is specifically not appearing in the technical specification but directly associated with the efficient working / completion of the system covered in the specifications.

Performance testing of various equipment associated with all fire services at manufacturer's works and also performance testing all mechanical Services System at site.

All necessary skilled/unskilled personnel, cranes, hoist, tools and tackles, instruments and accessories shall be arranged free of cost by the Contractor for assembly, erection, performance testing and commissioning of the systems.

Tenderer must note that completeness of System for safe, smooth, trouble-free operation and compliance with Local/International regulation is the sole responsibility of the Contractor i.e., the successful Tenderer. With this objective in mind, the Tenderer should include all the items essential for the efficient operation of the systems and other items which are required to complete the erection and foolproof commissioning of systems in respects. Whether the items are mentioned in the specification or not, all such items are treated/considered to be included in the specifications.

When any services passing the fire rated compartments/Wall or any barriers all sleeves or opening to be properly sealed with fire rated sealants.

Contractor i.e., the successful Tenderer shall be solely responsible to provide the above items at site without any extra cost implication to Client.

3.2 General Instructions to Tenderer

The technical specification inclusive of instructions/special instructions to Tenderer shall be read along-with General Conditions of Contract (GCC) and instructions to Tenderer, for the supply and erection of plant, machinery, and equipment.

All items of equipment in this specification shall be complete in all respect including mechanical and electrical equipment as specified including fasteners, bolts and nuts, gaskets, base frames, stiffeners, supports etc. and any item not covered in this specification but essential for superior design, operation and guaranteed performance of the system shall be included by the Tenderer.

The equipment shall be designed, manufactured and tested in accordance with the relevant international and local standards prescribed wherever possible.

The equipment offered shall be suitable for continuous, smooth, efficient and trouble-free services in the climate prevailing at the site, continuous duty conditions.

At the time of inspection, the Contractor shall furnish internal routine inspection certificate, material certificates, approved drawings, etc. to the inspector. Inspection shall be regarded as

check-only and shall in no way relieve the Contractor of his responsibilities to provide systems & equipment functions as designed.

The Contractor Shall take full responsibilities for the guaranteed operation and achieving rated out-put and performance of the systems offered as per relevant clause of specifications.

The Tenderer shall provide information required for the smooth functioning of the systems including operation, day-to-day maintenance, preventive maintenance, capital repairs, schedules and programs and any other information required by the Purchaser for trouble-free operation of the systems along with the supplies.

The scope of work for the Tenderer should not include provision of room and foundation for the systems. However, the necessary load data shall be furnished along with the offer by the Tenderer so as to complete the civil work at site as per the schedule of completion of respective buildings.

The Contractor shall ensure that all rotating elements viz impellers of fans and crank-shaft, piston assemblies shall be statically and dynamically balanced as per the relevant International / ISO standards.

The Contractor shall ensure that the speed of operation of all the mechanical and electrical equipment including technological auxiliaries and service equipment shall be kept low enough to reduce noise, vibrations and wear. When design parameters require higher speeds of operation of certain equipment, more than one stage shall be chosen over preference to choosing higher speeds.

The Contractor shall adhere to the schedule for supply, erection, testing and commissioning etc.

The Contractor shall ensure that each equipment is provided with name plate engraved in English language with the details like Supplier's address, operation and design parameters, weight, and precautions etc.

The Contractor shall ensure that the systems are designed considering the fire safety norms and adequate fire safety measures in the form of hardware interlock provided accordingly.

This section applies to all sections of plumbing services except as specified otherwise in the individual sections.

The work to be done under this section of the Specifications consists of the fabrication, complete in all details, at the subject premises, and all work and materials incidental to the

proper completion of the installation, except those portions of the work, which are expressly stated to be done by others. All works shall be in accordance with the governing Codes and Regulations and with the Specifications, except where it conflicts with such Codes, etc., the former shall then govern. The requirements in regard to materials and appliances, necessary for the complete installation of the work specified herein and indicated in the drawings. These specifications are intended to provide a broad outline of the required equipment but are not intended to include all details of design and construction.

Complete plumbing services shall be furnished and installed as shown on drawings and specified under this section. Coordinate timing of installation with work of other trades.

Systems provided shall be complete and operable, and shall include required accessories, fastening, and supports. One coat of primer shall be provided for all fastenings and supports.

3.3 Standard Codes and Regulations

All works performed, and equipment and materials supplied and installed under the contract shall comply in every respect with the rules and regulations of,

- ✓ Ministry of Defence and National Security of Maldives
- ✓ Maldives National Defence Force (MNDF)
- ✓ Current Edition of the Relevant British Standard Codes of Practice
- ✓ All other authorities have jurisdiction over the installation

3.3.1 Standards Compliance

Materials and equipment specified to conform to referenced standards and codes require proof of such conformance. Labels or listings indicating such compliance are acceptance evidence. In lieu of label or listings provide a certificate from an independent testing organization acceptance to the Engineer.

For materials and equipment whose compliance with organization standards or specifications is not regulated by listing or label, provide manufacturer's certificate of compliance.

Certificates of compliance shall identify manufacturer, product, referenced standards and manufacturer's certification that the product conforms to all requirements of the project specification and listed reference standards.

3.4 Authorities Inspection, Testing and Approval

The Contractor shall file all plans, application permits, etc., and shall complete all tests, forms, etc., arrange all inspection etc. as required by all rules and regulations, etc., of all the Government Authorities having jurisdiction and such shall be completed by personnel of proper caliber, in particular, Professional Engineers, where so required.

The work shall not be covered prior to the inspection and the approval of the authorities. The Contractor shall give due notice as required by the Authorities whenever such works are ready or about to be ready for inspection and testing. They shall afford full opportunity and co-operation of the authorities to carry out the inspection and testing and shall deemed to have allowed in the tender sum for such inspection, any fees payable, any necessary phasing and temporary suspension of works and other cost resulting thereby.

Should any work be covered without prior inspection and approval, the Contractor shall uncover any parts or part of the work or make openings in or through the same, as the Authorities may direct for inspection. The Contractor shall at its own expense reinstate and make good any such part or parts to the satisfaction of the authorities and Superintending Officer.

The Contractor shall furnish all required Certificates of approval.

3.5 Schedule of Technical Data and Manufacturer's Technical Pamphlets

Manufacturer's Technical Pamphlets giving full technical data for all equipment to be offered by the Tenderer shall be submitted together with the Tender. The schedule of technical data shall be duly filled. Equipment to be offered by the Tenderer shall bear both Manufacturer's Name and List Number.

Phrases like "As Specified", or "Equivalent", "Submit at a later date", will not be acceptable in the schedule of technical data.

Where there is a discrepancy between the schedule of technical data attached to the Tender documents and the specifications mentioned on manufacturer's technical pamphlets, the schedule of technical data should prevail.

Tenderers must fill in their tender strictly in compliance with the Engineer's base specification in regard to nominated makers of equipment/material. Any error in specifications must be clarified with the Engineer before submission of tenders, who will issue addenda thereof.

The original form of schedule of technical data must be filled in accordance with the Engineer's base specification or amendments thereof, failing which the client reserves the right to ask the Tenderer to comply with Engineer's base specification at tendered price or else the client reserves the right to forfeit the Tenderer's Tender Deposit and Tender Bond.

Tenderers are fully encouraged, however, to propose alternative specifications which can achieve genuine economy in cost or technical benefits, but these same alternatives and their cost implication thereof must be filled separately in a separate covering letter with a Schedule of Technical Data and not the original Tender Schedule.

3.6 Equipment and Material Approvals and Samples Review

Within 14 days after the award of any contract, the Contractor shall submit for approval a list of manufacturers of equipment and material proposed for the work. The Contractor's intent to use the exact makes stated in their tender does not relieve them of the responsibility of submitting such a list. All equipment and materials should be new and unused.

Wherever the words "equal", "approved equal", "as approved" appear in the specification, this shall mean approved in writing by the Consulting Engineer.

Each item of equipment shall be a standard catalogue product of an established, reputable, approved manufacturer. All similar equipment shall be of the same manufacturer, type, class and finish, unless otherwise specified.

Where manufacturer's catalogue numbers or types are specified or shown on the drawings, they are generally intended to be used as a guide and are not intended to take precedence over the basic duty and performance specified or shown. In all cases, verify the duty with the particular characteristics of the equipment offered for approval.

Where no alternative materials are noted in the specification or on the drawings and where the words "equal", "approved equal", or "as approved" etc., do not appear, the exact make specified must be supplied and installed. Equipment orders shall be forwarded to the Consulting Engineer for approval before purchase.

3.6.1 Samples

Where approval of products is specified submit samples or other evidence of suitability for review by the Engineer. Resubmit samples as necessary until an acceptable standard is reached. Do not confirm orders, commence manufacture or use products until approval of samples has been obtained.

3.6.2 Materials Application

Materials submitted for review shall be forwarded using a standard application format to be agreed with the Engineer. Enter the date by which review information is required. Allow a reasonable time for review and indicate urgency where necessary.

Where manufacturers are nominated in the specification or in the following schedule they are intended to define acceptable standards of equipment.

All necessary skilled/unskilled personnel, cranes, hoist, tools and tackles, instruments and accessories shall be arranged free of cost by the Contractor for assembly, erection, performance testing and commissioning of the systems.

Tenderer must note that the completeness of system for safe, smooth, trouble free operation and compliance with Local/International regulation is the sole responsibility of the Contractor i.e., the successful Tenderer. With this objective in mind, the Tenderer should include all the items essential for the efficient operation of the systems and other items which are required to complete the erection and foolproof commissioning of systems in respects. Whether the items are mentioned in the specification or not, all such items are treated/ considered to be included in the specifications.

Contractor i.e., the successful Tenderer shall be solely responsible to provide the above items at site without any extra cost implication to Client.

When any services passing the fire rated compartments/wall or any barriers all sleeves or opening to be properly sealed with fire rated sealants.

3.6.3 Review Categories

Shop drawings, Materials Samples and similar submittals will be reviewed and classified in one of the following categories:

- | | | |
|---|--|----------------------------|
| A | approved without comment | - no resubmission required |
| B | approved when comments are fully complied with | - no resubmission required |
| C | approved with comment/s | - to be re-submitted |
| D | disapproved | - to be re-submitted |

3.6.4 Equipment and Material Deviations

The dimensions and ratings of equipment specified herein or indicated on the drawings are intended to establish the outlines and characteristics of equipment furnished by the particular manufacturer or manufacturers specified.

Where the Contractor intends to use an item of equipment or material other than that specified or shown in the drawings or in the schedules, the Consulting Engineer's approval therefore must be obtained in writing.

Should any tenderer include in his offer equipment or material other than that shown in the drawings and schedules, such equipment or material must conform fully to the requirements for these items as shown in the drawings and schedules. Acceptance of any tender which includes equipment and material which differ in any respect to that equipment and material shown on the drawings and schedules, in no way relieves the Contractor from complying with the specification, drawing and schedules.

Where such approved equipment deviations require a different quantity and arrangement of piping, wiring conduit and equipment from that specified or shown on the drawings, the Contractor shall furnish and install any such additional piping, structural supports, electrical materials, insulation, controllers, motors, starters and equipment required by the system without additional charge.

3.7 Submittal

The following items shall be required to be submitted to the Engineer for review and certification.

a. System Design Calculation

Assumptions and basis of selection for the system components. Design calculations as required by the Engineer for review.

b. Design and Shop Drawings

Complete system design layout and description of components for all piping schedules.
Schedule and description of pipe fittings and valve.

c. Test certificates for the system.

3.8 Intent of Drawings and Specifications

It is the intent of the specification and drawings relevant to this Contract to call for finished work, tested and commissioned. Any apparatus, appliance or material not shown on the drawings, but which is mentioned in the specification or vice versa, or any incidental appliance or materials, services which may be necessary to make the work complete and perfect in all respect and ready for operation, even if not particularly specified, shall be furnished, delivered and installed without any additional costs.

The plans as drawn are based upon architectural plan and detail and show conditions as accurately as it is possible to indicate them in scale. The plans are diagrammatical and do not necessarily show all accessories, fixings etc., necessary to fit the building conditions.

The locations of outlets, apparatus and equipment shown on the plans are approximate. The Contractor shall be responsible for the proper location of all devices to make them fit with architectural details and instructions from Engineer's representative at the site.

3.9 Shop Drawings, Working Drawings and Details

After receiving approval of the equipment manufacturers submit for approval, without delay, and prior to purchase or fabrication, not less than three copies of detailed, dimensioned shop drawings or cuts of equipment showing general construction, size, arrangement, levels and setting out details, fixing details, operating clearances, related builders work information and requirements, performance characteristics and capacity of all specialties, together with sufficient engineering data to indicate substantial compliance with the respective specifications. Positions of all control equipment, including related components, shall be shown on shop drawings. Each item shall be identified by name and numbers as shown on the equipment schedules, control drawings and specifications.

Working drawings of the complete installation, prepared by the Contractor shall be submitted in triplicate for examination and comment. Each drawing will be examined and approved or corrected or disapproved by the M&E Engineers, and returned to the Contractor, who shall then print the necessary copies of each approved submission for distribution. Disapproved drawings shall be corrected and resubmitted.

Drawings shall be of 1:100 minimum scale, except in critical areas where 1:50 or larger scale as appropriate shall be used.

Inspection of shop and working drawings shall not be considered as a guarantee of measurements of building conditions. Where drawings are inspected, such inspection does not in any way relieve the Contractor from his responsibility nor from the necessity of furnishing material or performing work required by the contract drawings and specification, which shall, in the event of a dispute, take precedence over shop drawings.

The submission of shop and working drawings (in either the original submissions or resubmitted with corrections) constitutes evidence that the Contractor concerned has checked all information thereon and that they accept and are willing to perform the work as shown in a workman like manner and in accordance with the best standard practice. It also constitutes evidence that all control diagrams, all electrical diagrams and all submissions of any kind are fully understood by the Contractor and that in their opinion the equipment will perform as specified. No claim for extra shall be based on work shown on shop and working drawings, unless such claim is so noted on the Contractor's transmittal letter accompanying the drawings.

A responsible person of the Contractor's staff shall sign all drawings submitted, including those by suppliers.

Submit for approval within fourteen (14) days of the contract being awarded two (2) copies of a schedule of shop drawings showing the following:

- ✓ Drawing Number
- ✓ Title
- ✓ Planned Date of Submission

Dates of submission and approval shall be coordinated with the Building Programme. Shop drawings shall be submitted for inspection to the M&E Engineer, at a minimum of 14 days prior to the required return date.

Failure of the Contractor to include all shop drawings on this schedule shall not relieve them of their responsibility to submit all required shop drawings on time to permit correct processing as specified herein.

The subcontractor is responsible for ensuring that shop drawings are kept up to date incorporating modifications arising from instructions. Re-issue updated shop drawings as may be required by the Engineer.

3.10 Record Drawings, As-Built Drawings, and Operation and Maintenance Manuals

- Record Drawings

During the course of the work the subcontractor shall maintain fully detailed records of all changes from the tender drawings to facilitate easy and accurate preparation of the record drawings and to ensure that these drawings are in all respects a true record of the installation.

- Content

The drawings shall show the complete installation, including the size and runs of all ducts and pipework. The scales shall be such that details, particularly of the plant, can be clearly shown. The drawings shall show the names of the manufacturer, model and type numbers and all the details of duty and rating of all items of the plant. The drawings shall include the geographical location and identification number of each circuit control valve in accordance with the labeling and circuit control diagram.

- Diagrams

A print of each of the composite record circuit and layout diagrams shall be fixed securely to the inside of the hinged front of the main electrical control panels as appropriate, or in such other alternative positions as may be agreed by the Engineer and shall be protected by nonflammable transparent material. Where inadequate space exists, the prints shall be suitably reduced in size.

- Operations and Maintenance Manuals

The Contractor shall also provide Operations and Maintenance Manuals, wiring diagrams, valve charts, test certificates and the like as required by these specifications. Three copies of the Operations and Maintenance Manual shall be handed to the Engineer before practical completion. 2 copies of the O&M manual in CD format shall also be submitted. The files in the CD shall be in PDF or text format.

- Manual Format

The format of the manual shall be A4 size white paper for typed pages with neatly typewritten text, and manufacturer's printed data. Drawings shall be sized so that they may be folded to the size of the text pages. Each volume title of the manual shall be identified with the typed or printed title, Operations and Maintenance Manual, the title of the project and the identity of the general subject matter covered in the manual. Each manual volume shall contain a neatly typewritten table of contents arranged in a systematic order giving: Subcontractor, name of responsible principal, address and

telephone number, a list of the name, address and telephone number of the subcontractor or installer. Only the manufacturers printed data, which is pertinent, is to be included. Each sheet of manufacturer's instructions shall be annotated to identify clearly the specific item or part installed and the instructions applicable to the installation. All inapplicable information shall be deleted.

- **Supplementary Data**

Data shall be supplemented with drawings as necessary to illustrate clearly component parts of equipment and systems, control diagrams, flow diagrams and test procedures covered in the manual. Written text shall be organized into a consistent format under separate headings for different procedures and in a manner to provide a logical sequence of instructions for each procedure.

- **Organization**

Organize the Operations and Maintenance Manual as follows:

Volume 1

- ✓ Part 1 : Introduction
- ✓ Part 2 : System Description
- ✓ Part 3 : Operating Procedures
- ✓ Part 4 : Fault Finding
- ✓ Part 5 : Preventive Maintenance
- ✓ Part 6 : Appendices:
- ✓ List of Drawings
- ✓ Equipment Data and Spare Parts
- ✓ List of Manufacturers and Agents

Volume 2

- ✓ Publications (catalogues, selection tables, etc.)

- **Contents**

The content of the manual shall include those items contained in the above schedule and for each item it shall cover the following points:

- ✓ Description of plant, equipment, component parts and finishes
- ✓ Operating procedures, including step by step instructions for pre-start, starting up, normal operation and shutting down of the plant, equipment and components, safety features
- ✓ Maintenance procedures, including routine operations, guide to troubleshooting and fault finding, procedures for assembly, repair and reassembly, and procedures for alignment, adjusting, checking and cleaning

- ✓ Servicing, lubrication and cleaning schedule, including list of lubricants required and filter replacement
 - ✓ Manufacturer's printed operating and maintenance instructions
 - ✓ Circuit directories of panel boards, dial servicing and instrument checking
 - ✓ As installed color, coded wiring diagrams.
 - ✓ Details of each item of plant, including the name and address of the manufacturer and local agent, type and model, serial number, duty and rating.
- Operations and Maintenance Instructions

The Contractor shall demonstrate and explain the plant and the method of starting, running and stopping to the Consultant or the Employer's representatives. During the defects liability period the Contractor shall allow for providing trained operators to attend, operate and maintain the plant as directed by the Employer's staff. Demonstrate the purpose, function and operation of the installations including all items and procedures listed in the Operations and Maintenance Manual. Over this period the operators shall also instruct the Employer's staff in the correct maintenance and operation of all plant and equipment. The Contractor shall also assist the Employer in formulating any maintenance contracts with suppliers of equipment and Contractors that the Client may require. The Contractor shall provide three sets of operations and maintenance instructions (hard copies) and two soft copies of the O & M manual in CD format. The files in the CD shall be in PDF or text format.
 - Record Drawings (i.e. updated shop drawings)

Unless otherwise indicated, the Contractor shall provide the following drawings before the practical completion:

 - ✓ 3 sets of installation working drawings.
 - ✓ 3 sets of detailed plant room drawings.
 - ✓ 3 sets of purpose made diagrams detailing separately all the composite electrical circuit and wiring layouts.
 - ✓ 3 sets of builder's work drawings.
 - ✓ 1 set of reproducible fitted drawings, process negatives and computer discs for use with AutoCAD upon completion of the work

- **Completion**
Adjust copies of all Shop Drawings to record final installation. Submit three complete finalized sets before practical completion. Supply copies of all associated supplementary manufacturers or other data necessary to form a full and complete record of work done.
- **Additional Data**
Provide details of any errors, variations, omissions or additional information which is not instructed, directed or indicated on the subcontract drawings, but which becomes apparent from construction. Information is to enable record drawings to form an accurate record of final construction.
- **Manufacturers' Input**
Retain copies of maintenance instructions and documents delivered with components and equipment or obtain from manufacturer as necessary and submit before Practical Completion.
- **Spare Parts**
On completion of the testing and commissioning of the mechanical services installation, spare parts required by the specification shall be supplied and submitted.
- **Lists**
At the time of handover provide a comprehensive list of all manufacturers, suppliers and local agents for all items used in the construction of the works. Include the following data:
 - ✓ Product/service
 - ✓ Specification/instruction reference
 - ✓ Company name
 - ✓ Address
 - ✓ Telephone and emails
 - ✓ Contact name, title and position.

Upon completion of the job, the Sub-Contractor shall furnish to the Owner their original tracings or reproducible transparencies of all electrical works, shop drawings and equipment layouts. They shall note on the as-built drawings furnished by them, the corresponding number of the applicable shop drawings. Where shop drawings are not available, the Contractor shall neatly indicate the changes on the as-built drawings.

- As-Built Drawings

On completion of the installation, the Contractor shall prepare a set of As-built drawings incorporating all changes made to the original design and drawings, which drawings shall represent an accurate description of the installed systems. These drawings shall be bound with covers into an album and handed over to the Engineer.

3.11 Quality Assurance

The Contractor shall operate and maintain a Quality Assurance programme to ensure that the Contract is completed in accordance with the approved programme and to the standard specified. Work procedures shall be documented and shall be available to satisfy the effectiveness of this programme in the following areas at contract execution.

- ✓ Design
- ✓ Procurement, manufacture and packaging
- ✓ Construction and erection
- ✓ Manufacturer's Instructions

Where installation procedures are specified to be in accordance with the manufacturer's instructions, provide published copies prior to installation. Installation of materials and equipment will not be allowed until the instructions are received. Failure to furnish manufacturer's instruction can be caused for rejection of the materials.

- Completion and protection:
 - ✓ Protection

Protect building finishes, fixtures and fittings and prevent damage to existing property. Move, cover and protect as necessary to enable the work to be executed and replaced in original positions upon completion.

- ✓ Special Protection

Wherever work is of an especially vulnerable nature or is exposed to abnormal risks provide special protection to ensure that damage does not occur. Replace or repair any damaged components or finishes.

- ✓ Waste Material

Remove rubbish, waste, debris and surplus material regularly and keep the site orderly and clean. Remove all rubbish, dirt and residues from voids and cavities

in the construction before closing in. Dispose of waste material at an approved location and obtain all necessary permits.

✓ Cleaning and touch up

Remove all temporary markings, coverings and protective wrappings unless otherwise instructed. Clean finished work thoroughly, remove all surplus material. Cleaning materials and methods shall be recommended by product manufacturers. Touch up minor faults in finishes or repaint badly marked areas back to suitable breaks or junctions.

- Lubrication

Adjust, ease and lubricate moving parts of new work as necessary to ensure easy and efficient operation.

- Defects

Defects are to be reported to the Engineer without delay. Obtain directions before proceeding with work which may cover up or otherwise hinder access to defective construction or be rendered abortive by the carrying out of remedial work.

3.12 Practical Completion & Handing Over

- Preparation

During the weeks leading up to practical completion, the employer and the engineering Consultants will monitor commissioning tests with the Contractor and his subcontractors. A programme of such tests is to be agreed well in advance to ensure a systematic and progressive approach towards building handover. The Contractor shall pay particular attention to the production of Record Drawings and Maintenance Manuals. Their production will be progressively reviewed in order that they are finished by the Date of Completion.

- Preparatory Inspection

Two weeks prior to the anticipated date of Practical Completion a formal inspection of the works will be undertaken jointly by the Architect, engineering Consultants and the Contractor. The Employer will be invited to send representatives to this inspection. Lists of defective and incomplete work are to be prepared together with the engineering Consultants, together with a check list of outstanding documentation related to the

documents required to be handed over by the Subcontractor at practical completion. The engineering consultants will consolidate these lists and forward to the Subcontractor for action. Action related to the lists will be monitored in the remaining period to practical completion.

- Handover

As soon as the consultant is of the opinion that practical completion has been achieved, he will arrange a formal handover inspection with the Employer. Any remaining defects or pending documentation will be listed for immediate action by the Subcontractor within seven days unless otherwise instructed by the consultant.

The final handing over documents to be submitted by the Contractor on completion of the installation shall comprise the following:

- a) Operation and maintenance manuals (3 copies)
- b) Commissioning sheets (3 copies)
- c) Test reports (3 copies)
- d) As built drawings (3 hard copies and 1 soft copy in CD)

These documents, in required number of copies specified, should be supplied to the Employer/Consultant within 30 days on the issue of taking over certificate.

- Defects Liability Period

Defects will be reviewed at joint site inspections with Consultants and Contractor. The Consultant will coordinate input from all disciplines and prepare a defects list that will be updated and reissued following inspections throughout the Defects Liability Period. Permission for access to accommodation for making good defects is to be obtained strictly in accordance with Employer, Contractor and user requirements. Defects are to be made good promptly and expeditiously.

- Training

The Contractor shall allow in his contract price the service of a competent personnel to instruct the Owner's maintenance staff in the operation and maintenance of the installation and equipment during the initial operation of the system, subsequent to the issue of the certificate of practical completion or handing over of the works to the owner whichever is earlier.

- Maintenance and Guarantee

All equipment supplied and installed shall be in good working order and shall be guaranteed for a period of 12 months from the date of handing over the completed installation to the Owner. This guarantee shall include the equipment manufacturer's standard warranties and the Contractor's own guarantee on all other materials supplied and installed by them.

The contractor shall make good any defects to the components of the equipment that may arise from fair wear and tear during the guarantee period. Any component of the installation which fail to achieve the guaranteed performance to be replaced by the Contractor without delay and without any charge.

During the above-mentioned guarantee period the Contractor shall provide free regular monthly maintenance to all plumbing services and ensure that all systems are maintained in first class running order. The maintenance shall include systematic examination, cleaning, adjustments, testing and lubrication and shall cover replacement of parts due to fair wear and tear. During this guarantee period the Contractor shall also provide emergency breakdown maintenance.

The Contractor shall maintain a detail record of all services, maintenance and repair work carried out. Such record shall be prepared in duplicate and should be in a form of Maintenance/ Repair sheet, with one copy to be retained by the Owner upon the execution of such services. Records of such service, maintenance or repair shall also be entered in the maintenance logbook provided at the site.

The bidder shall submit the terms and charges for service and maintenance contracts along with the bid.

3.13 Testing & Commissioning

Bidders shall submit with the bids a complete proposal with a time schedule for testing and commissioning of the plumbing systems. The program shall include a trial operation of all main equipment with any necessary adjustments to ensure that the system is working correctly. The Contractor shall provide all instruments and equipment together with commissioning engineers and adequate assistance for carrying out the commissioning and testing activity which shall be done in accordance with the recommendations of relevant standards. If any portion of the work fails to pass the tests, the Contractor shall, at his own expense carry out such alterations or replacements as

are required to the satisfaction of the Engineer. The Engineer shall be at liberty to call for further commissioning when such alterations have been completed to their satisfaction. The Contractor shall provide commissioning spares at his own expense. Spare parts earmarked for maintenance shall not be used during this period.

2 Fire Protection System

2.1 System Description

Centralized fire protection system is provided for the building. There is a pump room at Basement level to install hydrant pumps, main vales and control panels.

Fire protection of the building consists of the following sub systems:

- Wet Riser system with Hydrants and Hose Reels:
Landing vales and hose reels are provided inside the building at the fire-fighting lobbies and main lobbies as required.
- Fire Suppression System for the Server room and HVAC control room
- Portable Fire Extinguishers:
Water, CO₂, ABC Dry Power portable fire extinguishers are provided throughout the building as per the requirements

Required numbers of wet risers are provided inside the building as per BS and all the landing valves and hose reels are connected to the riser. The landing valves will equip with pressure regulating valves.

Hydrant pump set consists of duty pump, stand by pump and jockey pump.

Hydrant pumps shall be installed in the pump room. Water for the wet risers shall fed from the adjacent fire sump (positive suction) through the hydrant pump sets.

Fire sump capacity is 50,000litres and directly fed from the MWSC city water supply line. The water supply pipeline shall be 110mm diameter.

2.2 Regulations and Standards

The system and its components shall comply with the local by-laws, regulations and standards where applicable:

- Regulations of Ministry of Defence and National Security
- Requirements of Maldives National Defence Force (MNDF)

- Latest editions of following British Standards
 - BS 5306-1- Code of practice for fire extinguishing installations and equipment on premises. Hose reels and foam inlets
 - BS 5306-3 - Fire extinguishing installations and equipment on premises Commissioning and maintenance of portable fire extinguishers. Code of practice
 - BS EN 3 – Portable fire extinguishers
 - BS 5041-3 - Fire hydrant systems equipment. Specification for inlet breechings for dry riser inlets
 - BS 336 - Specification for fire hose couplings and ancillary equipment
 - BS EN 671-1 - Fixed firefighting systems. Hose systems. Hose reels with semi-rigid hose
 - BS 9990 - Non automatic fire-fighting systems in buildings Code of practice
 - BS 9999 - Fire safety in the design, management and use of buildings. Code of practice
- Latest editions of NFPA standards

2.3 Scope of Works

Scopes of work are as follows but not limited to the following:

- i. Supply and installation of all equipment and material required for Fire Protection system.
- ii. Preparation of shop drawings conforming to the requirements of MNDF with amendments (if any) required in Tender Drawings for conforming to requirements of authority.
- iii. Providing required labor for installation of the complete system.
- iv. Testing, commissioning and handing over the system after successful completion.
- v. Obtaining certificate of conformity from MNDF on completion of work.
- vi. Submitting sets of operation and maintenance manual and necessary software
- vii. Maintenance during installation and defect liability period.

The contract shall comprise of the following works to provide a fully operational system: -

- Wet riser pump set complete with controls and starter panels.

- Hose reel assemblies
- Piping, valve fittings, orifice plates, pressure gauges and etc.
- Wet riser water storage tank accessories

The installation shall be complete in every respect, including all fittings, materials and accessories necessary for the complete functioning of the system.

2.4 Design Conditions

Water quantity at furthest three hydrant connections:	1500 l/min
Pressure required at furthest hydrant connection valve fully open:	4 bar (min)
Water quantity at furthest hose reel connection:	30 l/min
Minimum pressure required at hose reel nozzle:	1.25 bar

2.5 Other Requirements

1. If the specification, capacities and sizes given are not adequate or have to be changed to suit an equipment of any manufacturer for producing required design conditions the Contractor shall include his charges for these with the quotation. Once the contract is awarded no extra cost will be made to the Contractor for such changes.
2. All the materials shall be new without any defects and to be approved by the Engineer.
3. All the approvals required to be obtained prior to the installation and after the completion shall be obtained by the Contractor from the respective Local Bodies.
4. All builders work required with respect to plinths and foundations, opening on walls (both concrete walls and brick/bock walls) and floors and any additional provisions required shall be included in the Scope of Work.

2.6 Fire Pumps – General Specifications

Fire pumps shall be listed, either UL/FM or LPCB.

2.6.1 Major Components

Pumps shall consist of:

- Casing impeller

- Suction and discharge connections
- Driven shaft
- Couplings
- Motor
- Shaft seal

(Pumps shall be complete with shaft water seals).

The motor terminal box shall be suitable for flexible conduit connection. Installations shall comprise:

- eccentric reducers for suction pipes and concentric reducers for discharge pipes
- expansion pieces directly connected to the pipe connection
- vibration isolation equipment
- gland drain and tail pipes arranged to discharge into an open turn dish adjacent to the pump base
- Support brackets or plinths incorporating anti-vibration material

Pumps and supplementary assemblies shall be entirely suitable for the systems pressures and temperatures specified in Drawings or Bill of Quantities.

Gate valves shall be provided on suction and discharge. Strainers shall be fitted on the inlet unless otherwise specified.

Pump duties shall be achieved with the impeller shaft speed not exceeding 48rev/s (2900rpm) unless otherwise specified. Where duty and standby pumps are required, provision for automatic changeover shall be made with non-return valves fitted in each pump discharge line.

Pump connections shall be screwed to BS EN 10226 up to DN 50 and flanged to BS EN 1092 Part 2, PN 20 or PN25 as required (1.5 times the system pressure) for DN 65 and above.

Pump suction and discharge flanges shall be drilled and tapped for pressure gauge connections. Closing plugs shall be supplied.

Pump casings shall have drain plugs fitted at the lowest point. Direction of rotation shall be indicated. All drive connections between drivers (motor or engine) and pumps shall be fully protected against accidental contact. Provision shall be made for shaft speed measurement.

Each pump shall be furnished with splash guards where applicable. Pumps shall be correctly aligned before start-up.

Tied bellows type flexible pipe couplings shall be installed at all pipework connections to pumps. No pump load shall be imposed on the connecting pipework.

Impellers and couplings shall be keyed to the drive shaft, the impeller being retained by a hexagonal nut. Shafts shall be fitted with water deflectors.

2.6.2 Material of Construction

Pump Component	Cast Iron	Stainless Steel	High Grade Gun- Metal	Phosphor Bronze
Casing	x			
Seal Housing	x			
Baseplate	x			
Sub-frame	x			
Shaft		x		
Impeller			x	
Renewable Casing				
Wearing Rings				x
Glands shall be fitted with a self-adjusting mechanical seal unless otherwise specified.				
Impeller shaft extensions shall have a liquid shield.				

Generally, materials used for construction shall be:

- Pump casings : close grained cast iron
- Impellers : cast iron or gunmetal (bronze)
- Shafts : stainless steel

The permissible service pressure of cast iron pump casings shall be generally in accordance with the manufacturer's recommendations. No pump part or component part shall be subjected to a gauge pressure in excess of 16 bar, except where specifically listed in the equipment data sheets.

2.6.3 Pump Operation

Jockey Pumps

The Jockey pumping system shall operate as follows:

- A fall in the piping installation pressure shall activate the pressure switch.
- The pressure switch transmits a signal to the pump control panel with automatically operates the electric jockey pump.
- The pump control panel shall indicate the actuation of the pump and transmit a signal to the Fire Alarm Control Panel
- The Fire Alarm Control Panel shall indicate the operation of the jockey pump both audibly and visually.
- If the pressure in the piping system falls further down a second pressure switch shall actuate the main duty pump
- A signal shall be displayed at the Fire Alarm Control Panel and pump control panel indicating the operation of duty pump.
- Upon failure of the duty pump and/or further pressure drop in the piping Installation a third pressure switch shall actuate the standby pump.
- A signal shall be displayed at the Fire Alarm Control Panel and pump control panel indicating the failure of the duty pump and/or the operation of the standby pump.

2.6.4 Pump Name Plates

Each pump shall be provided with a plate giving the output pressure at zero suction lift at the nominal flow rating. Where the performance characteristic of the pump is to be achieved using an orifice plate not integral with the pump delivery, the plate shall carry a reference to the fact that the performance given is that of the pump and orifice plate combination, together with the 'K' factor of the orifice plate.

In all case, the pump plate shall give the rated speed for the pressure and flows specified and the maximum power absorbed at the rated speed.

2.6.5 Controls for Fire Pumps

The controller shall be arranged to include the following minimum requirements and specifically tested for fire pump service, all in accordance with local authority requirements:

- Manual/Automatic control of the duty and stand by fire pumps with constant output governed by the discharge pressure control situated in the distribution mains.
- Operation of the fire pump sets in a duty/standby mode with manual facility for lead pump selection. The standby pump shall be set to come into operation on failure of the duty pump.
- The 'OFF-MANUAL-AUTOMATIC' selection sequence shall be controlled by a three-way switch. Any position other than AUTOMATIC shall sound an alarm.
- In addition to the automatic and manual starting systems, the control panel shall be provided with a device that will enable the pumps to be started from the control circuit in case of any failure.
- Operation of the controls shall be possible from the front of the panel without the need to open the panel doors.
- Pressure switches shall be provided for the starting of the pumps when the pressure in the fire service distribution main falls to a value not less than 80% of the rated operating pressure unless otherwise specified. The pressure switches shall have independent high/low calibrated adjustments and be able to withstand a hydrostatic pressure of 300% of the rated working pressure for five (5) minutes.
- Once started, the pumps shall run continuously until manually stopped or when the system pressure has reached the cut-out pressure setting. Starting of the pump(s) shall at the same time initiate a visual and audible alarm.
- The controllers shall be provided with pilot lights, common alarm bell and individual contacts for the connection of remote signal devices which operate in the event of the following: -
 - AC power failure
 - Failure of duty pump to start
 - Failure of standby pump to start
- Provision in the form of contacts shall be included for the connections for remote alarm and signals which correspond to the pilot lamps in the controller.

- All alarm and signals shall be able to operate under manual as well as automatic conditions.
- Audible alarms shall be of minimum 85-dBA rating at a distance of 5 m.
- An electric motor lockout shall be provided for dis-connection of any wires that interconnect the electric motor control and shall not interfere with the proper operation of either controller.
- The fire pumps shall be monitored by the Main Fire Alarm Panel.

2.6.6 Pump Control Panel

The fire pump control panel shall be a self-contained, extensible, wall- mounted flush-fronted metal cubicle board completely assembled, wired, and tested by the Fire Pump Supplier/Installer before delivery from the Factory. The controller shall be so arranged as free standing independent from the pumps and the contractor shall indicate if the controller is to be supplied with the enclosure designed to be inspected and service from the rear. The controller shall be fixed not further than 3 m from the pump, and be within sight of the pump.

The pump control panel shall be designed to receive an electrical supply of 415/240 V, 3 phase, and 50 Hz AC current. All motor starters shall be incorporated within the control panel. The control panel shall incorporate spare contacts that will close upon operation of the electrical and/or any warning signal. The contacts shall energize a remote electrical bell/or lamp within the main Fire Alarm Panel.

All switches, which are required to keep the controller in the 'Automatic' positions shall be within locked cabinets having break glass panels.

All other items as required or standard to, the manufacturer's equipment shall be supplied.

2.6.7 Pump Performance Tests

The fire pumps shall be tested for its performance prior to delivery to site at the pump manufacturer's factory. The pump casing hydrostatic test shall also be carried out in accordance to the Hydraulic Institute Standards. All testing certificates shall be submitted to the Engineer for approval prior to delivery.

The fire pumps shall also be tested for its head/flow characteristic under normal operating conditions after the installation.

2.6.8 Electric Motor for Fire Pumps

The electric motors shall be AC squirrel cage induction motor of the totally enclosed fan cooled (TEFC) type. The motor shall be in compliance to BS 5000 and of sufficient capacity to effectively fulfill the pump horsepower requirements. The continuous maximum motor rating shall have a minimum overload factor of 15% in excess of the power requirements at maximum pump discharge and minimum total head condition.

The motor windings shall be insulated to BS 2757, class 'F' and suitably impregnated to withstand damp tropical conditions. Anti-condensation heaters shall be fitted for motors 10 HP and above. Stator frames, end shields, terminal box and cover shall be cast iron or other approved material. Fan and fan cowl shall be of corrosion protected material.

The motor shall be suitable for 415V, 3 phase, and 50 Hz power supply. All electrical works pertaining to the motor installation shall be provided. The motor shall be suitably earthed and provided with an overload trip protection. The thermistor protection is not required.

The motor shall comply with all the regulations of the local authorities and be provided with an approved type motor starter to limit the inrush starting current. Starters for the pump's motors shall be direct on line for motor with 1 to 3 Hp, star-delta for motor with 3 to 10 Hp and auto-transformer for 10 Hp and above. The starting current shall not exceed 150% of full load current. Capacitors shall be incorporated where necessary to maintain the power factor of the installation to 0.85 or higher. Unless otherwise specified, motor starters shall be to BS 4941:

- Suitable for three-phase, four-wire 415/240V 50Hz ac supply.
- Fitted with 220-250V ac operating coils.

The pump motor shall generally be flanged motor and suitable for horizontal operation. Coupling between the pump and the motor shall be by flexible self-aligning type complete with bolt-type metal guard. The pump and motor combination shall be mounted on a common base-plate of heavy-duty fabricated steel or cast iron and the complete unit installed on a suitable foundation plinth. The plinth shall be provided to suit the Manufacturer's requirements. Mounting of the pump sets on the plinth shall be complete with proper drainage and adequate vibration padding or an isolating efficiency of not less than 95% against the lower fundamental disturbing frequency. The minimum acceptable static deflection in the spring and shall be 1 inch (25mm) for machines having a fundamental frequency of 1000 rpm or above, increasing to 1/2 inch (40mm) at 500 rpm. Spring mounts shall be fitted with approved levelling devices.

The electric and power supply to the motor shall be always available. Any switches on the power feed to the motor shall be clearly labelled 'POWER SUPPLY FOR FIRE PUMP. DO NOT SWITCH OFF'. An indicator lamp or lamps shall be provided to show that the power is available to the motor. In the event of power failure to the motor starting switch, an automatic warning shall be given visually and audibly at the Main Fire Alarm Control Panel.

The pumping system shall operate as follows:

- A fall in the piping installation pressure shall activate the pressure switch.
- The pressure switch transmits a signal to the pump control panel with automatically operates the jockey pump.
- The pump control panel shall indicate the actuation of the pump and transmit a signal to the Fire Alarm Control Panel (FACP).
- The Fire Alarm Control Panel shall indicate the operation of the jockey pump both audibly and visually.
- If the pressure in the piping system falls further down a second pressure switch shall actuate the main duty pump
- A signal shall be displayed at the Fire Alarm Control Panel and pump control panel indicating the operation of duty pump.
- Upon failure of the duty pump and/or further pressure drop in the piping installation a third pressure switch shall actuate the standby pump.
- A signal shall be displayed at the FACP and pump control panel indicating the failure of the duty pump and/or the operation of the standby pump.

2.6.9 Pump Efficiency

Pump efficiency shall not be less than the following:

Shaft kW	Minimum Efficiency
Up to 1 kW	0.35
1 to 2 kW	0.5
2 to 5 kW	0.6
5kW and above	0.7

2.6.10 Jockey Pumps

Jockey pumps shall maintain system pressure on the installation side wet riser system. The following general requirements shall apply to jockey pumps:

- A fall in the system pressure on the installation side of the control valve will activate the pressure switch controlling the Jockey Pump.
- The pressure switch transmits a signal to the jockey pump control panel and activates the jockey pump to maintain system pressure on the installation side of wet riser system.
- Jockey pump shall have rated capacities not less than normal leakage rate and sized to make up the allowable leakage within 10 minutes at a rate of flow not exceeding 4 l/min.
- Jockey pump shall have a shut-off pressure not exceeding the working pressure rating of the fire protection equipment.
- The power supply to the jockey pump shall be such that any failure of this pump does not affect the power supply to the main fire pump.

Starter provisions and controls for each jockey pump shall be such that any failure of this pump panels.

Jockey pumps shall be low capacity in line centrifugal pumps. Pump impeller and shaft shall be stainless steel with a cast iron casing. Motors shall be totally enclosed, fan-cooled, squirrel-cage type.

2.7 Wet Riser Fire Hydrant System

2.7.1 Scope of Works

Shall comprise of the following works to provide fully operational system: -

- 150mm diameter wet riser piping for landing valves
- Landing valves (pressure regulating type), canvas hose, hose cradle, coupling and nozzle
- 65mm diameter wet riser piping for hose reels
- Hose reels with pressure reducing valves, union and ball valves
- 2-way breaching inlet directed to fire pumps discharge header pipe

- Pump and sump connection piping, valves, control panels and all other accessories as indicated in drawing related to wet riser system.

The installation shall be complete in every respect, including all fittings, materials and accessories necessary for the complete functioning of the system.

2.7.2 Fire Sump

The water sump for fire services is situated at basement level. The capacity of the water sump should be 50,000litres. Water supply for the fire protection system will be drawn from this sump. The fire sump shall be complete with all necessary provisions such as:

- Access openings with covers
- Water supply connection connected to city main
- Ladder or SS rungs
- A level gauge shall be provided and installed in an easily accessible location in the pump room so that the actual content of the water sump can be visually determined

2.7.3 Wet Riser Fire Pumps

Fire Pump set completely assembled shall consist of followings.

- 02 Nos. of end suction type centrifugal listed positive suction pumps (duty/standby) with electric motors 400V/50 Hz Capacity of each pump: 1500 l/min at 96m head
- 1 No. vertical multistage centrifugal “inline” pump with electric motor 400V/50Hz (jockey pump), Capacity of pump: 60 l/min at 103m head
(Both Main and Jockey Pump heads need to be verified with the shop drawings by the Fire sub-contractor)
- Pressure switches & flow switches for commanding the pumps
- Pressure gauges dia. 63mm 0-20 bar
- Pressure tank
- Non-return valves with coupling
- Shut off valves
- Suction pipe works with vortex inhibitors
- Delivery header

2.7.4 Pump Control Panel

➤ Control Philosophy

Fire Pump Set in Automatic Control Mode:

- a. Jockey pump should maintain system pressure at 1.0 bar higher than design system pressure and should cut in before main pump at low demands and cut off at 1.0 bar above cut in pressure
- b. Duty pump (main pump) shall cut in when the system pressure drops by 1.0 bar against pre-set pressure level as dictated by the system.
- c. Standby pump shall cut in on failure of duty pump (main pump) or a pressure loss on the system
- d. Auto pump selector switch shall select lead fire pump alternatively
- e. Pumps shall run until they are manually shut off

Fire Pump Set in Manual Control Mode:

- a. Any pump shall be able to On / Off manually
- b. Lead / Lag pump selection shall be possible manually

Indicator Lamps, Controls and Instruments on Pump Control Panel are as follows but not limited:

- LI, L2 and L3 phase indication with R, Y, B lamps
- On / Off/ Fail lamps for each pump
- Indicator lamps and lamp test switches
- Lead / Lag pump selector switch
- Auto / Off/ Manual mode selector switch
- Main ON / OFF switch
- Fail alarm and mute switch
- Voltmeter with phase selector switch
- Ammeters for each phase with maximum demand indicator
- Water sump level indicator (Audio & Visual)

Protection only for the Jokey Pump and interfacing are as follows but not limited:

- Pump set dry run protection by float switch
- Single phasing cut off
- Thermal overload protection for each pump motor

- Interfacing with fire detection and alarm system for status indication

Control Panel construction and main components are as follows but not limited;

- The control panel shall be powder coated steel panel rated IP 54 with lockable door
- Star-Delta / DOL starters for pumps
- Main incomer breaker
- Breakers for all outgoing feeders to pumps
- Main bus bars and earthing bus
- Programmed switch for automatic change over and delayed cut-out signal
- Contactors, relays, interlocks, CT's fuses, etc.

2.8 Fire Equipment

All items mentioned below shall be listed, either UL/FM or LPCB.

2.8.1 Fire Hose

In the fire cabinet located as indicated in the drawings synthetic fire hose of 65mm dia. (2 1/2") made of nylon and totally covered with PVC lining shall be provided along with rubber hose reel of 19mm dia. each 30m and/or 45m in length. Fire hose shall be light weight and flexible with woven synthetic jackets and zone resistant, seamless rubber, smooth-bore lining suitable for fire brigade use. They shall be certified by makers to withstand an internal water pressure of not less than 40 bar without bursting. They shall also be capable of withstanding a working pressure of 18.5 bar without leakage or undue sweating. The branch pipes shall be light alloy complete with spray/jet diffuser nozzle, 16mm (5/8") orifice and 2 1/2" male instantaneous British inlet.

Each hose length shall be indelibly marked to identify the fire station or wall to which it belongs and numbered. The precise marking shall be agreed with the Engineer. Fire hose shall be confirmed to BS 336. Canvas hose shall not be placed on floor. The nozzle shall be of approved jet/spray type and Couplings shall be of gunmetal or other corrosion resisting material, which is sufficiently robust to withstand rough treatment.

2.8.2 Landing Valves

The landing valves shall be of gunmetal construction with 2 1/2" BST flanged inlet and oblique 2 1/2" female British Standards instantaneous outlet to ensure compatibility with the local fire authority equipment. A blank cap also of gunmetal and a chain shall be fitted to each

landing valve. The landing valves shall be of the controlled pressure type (Pressure regulating type) designed to enable a uniform firefighting pressure to be maintained at any hydrant irrespective of its location in the building. The valve shall be so designed that the seal may be replaced or the gland re-packed when under pressure with the valve fully closed. The valve shall be provided with a means for attaching a strap so that the hand wheel is secured to prevent unauthorized use. A purpose-made strap made of leather or reinforced plastic material not less than 12mm wide nor less than 2mm thick and a small non-ferrous padlock to secure the two ends of the strap shall be supplied with each valve. The manufacture of the valves shall provide a test certificate to conform that the valves have been submitted to the tests described in BS 5041 Part 1 and shall certify that they have satisfactorily achieved the performance required. The landing valve shall be installed with its lowest point about 750mm-900mm above the floor level.

2.8.3 Fire Hose Reels

Hose reels shall be provided internally at each fire cabinet as shown in the drawings. Hose reel shall be of the manual swing type (according to location and as scheduled) complete with 30m and/or 45m of 19mm (internal diameter) non-collapsible, non-kink reel hose and nylon spray/jet/shut-out nozzle. To facilitate the ease of installation and maintenance, a gate valve and union shall be fitted between the rising main and the hose reel. Pressure reducing valve shall be provided to branch pipe at each fire cabinet to maintain maximum allowable pressure of Fire hose reel and accessories. The hose shall comply with the requirements for type A (design working pressure of 15 bar) hose specified in BS EN 1947. Each length of hose shall be durably marked at the nozzle end and at intervals not exceeding 10m, with the following information:

- (a) Manufacturer's name or identification
- (b) The number of the specified BS with the type letter suffix e.g. BS 3169/A
- (c) The nominal bore size, e.g. 19mm
- (d) Month and year of manufacture e.g. 10/2007
- (e) The design and working pressure

This information may be conveniently presented in the following manner.

MR/BS 3169/A/19mm/10/2007/15 bar

Hose reel brackets shall be firmly fixed to the wall so that casual knocks received during normal use of the building and the stresses incurred during use for firefighting will not prevent the unimpeded use of the hose reel.

The hose reel assembly shall be suitable for swift withdrawal of the hose in any direction. Each hose reel assembly shall consist of a rubber hose, a metal reel, a stop valve, a hose guide and nozzle. The whole hose reel assembly is permanently connected to the water supply.

The reel shall be of metal construction of not less than 8 in. (200mm) inner case diameter and not more than 30 in. (750mm) rim diameter. It shall extend not more than 18 in. (450mm) from the wall or mounting surface. The side plates shall extend at least 1/2 in. (12mm) radially beyond the wound-up hose.

The nozzle assembly shall be constructed of gunmetal, brass or other sufficiently robust and corrosion-resistant material. The nozzle shall be permanently marked to indicate the open and shut position.

The whole hose reel assembly shall rotate on the horizontal axis and the water supply connection to the hose shall be arranged such that the hose is not obstructed or kinked when the hose is wound up.

A pressure reducing valve shall be provided for the hose reel for controlling the static pressure to within 1.25bar – 2.00bar. The nozzle shall be adjustable for spray and jet discharge.

Every hose reel assembly shall bear the name of the manufacturer and the instructions for operation. Where hose reels are located in recesses or in non-prominent positions, a notice bearing the words “FIRE HOSE REEL” in red letters on a white background shall be provided. Hose reels shall be provided with recessed housing.

2.8.4 Fire Service Inlet

For the wet riser system and the sprinkler system 2-way inlet type breaching inlet shall be provided to fill the water sump considering the building is a high rise building in the position shown in the drawing. The breaching inlet shall be of light alloy construction with gunmetal fittings, built in non-return valve and instantaneous inlet to match the requirements of the local fire authority (MNDF). The breaching shall be accommodated in a recessed galvanized steel breaching cabinet complying with the requirements of BS 5041 Part 5. The door shall be fitted with a lock and wired glass panel lettered in red “BREECHING INLET”.

The breeching shall be fitted with a drain valve in the form of a 1” gate valve complying with BS 5154, rating PN 20. The drain valve outlet shall be positioned so that it faces in the same direction as and is at a lower level than that of the inlet connections to the breeching. The outlet of the drain valve shall have 1” male threads complying with BS EN 10226 and shall be fitted with a female blank cap and chain.

A plastic or rubber cap shall be fitted to the inlet of the breeching attached by a suitable lug, Shook and chain. The manufacturer of the inlet breeching shall provide a test certificate to confirm that it has satisfactorily achieved the performance required.

2.8.5 Fire Cabinets

Fire cabinets shall be located as indicated in the drawings. They shall be fabricated out of 1.5mm thick steel sheet and protected with a coat of epoxy-based zinc chromate enamel red paint. The doors shall have wired glass panel and shall be hung on piano hinges to be openable through 180° swing. The door shall also be fitted with a break glass type cubical and the key shall be kept in it. The door should bear the word “FIRE HOSE CABINET” in red letters at least 50mm high on a white background.

2.8.6 Air Release Valve

Approved type automatic air release valve shall be provided at the highest point of every main riser to allow air in rising main to discharge to the atmosphere when water is being pumped in. Each air release valve shall be complete with an isolating valve and piped to the nearest drain or waste.

2.8.7 Pressure Relief Valve

A pressure relief valve shall be provided on a branch off the pump discharge before the non-return valve with the outlet piped to discharge over the suction tank.

2.8.8 Test Pipe

A test pipe branch with valve shall be taken from the discharge pipe, after the non-return valve assembly, and extend to discharge over the suction tank.

2.8.9 Earthing

The rising mains shall be electrically earthed to the external of the building. Earthing resistance shall not exceed 1 ohm.

2.8.10 Calibration

Each landing valve shall be separately adjusted to deliver water in accordance with local fire authority requirements.

2.8.11 Testing

The complete installation shall be tested hydraulically to one and a half times the working pressure measured at the base. The pressure should be maintained over 24 hours and shall not drop more than 5% after correction for temperature.

2.9 Pipes

2.9.1 Pipe Material

All main riser pipes shall be ASTM Schedule 40 Grade B, Type S (Seamless Galvanized Steel Pipes) and all associated pipe work shall be galvanized steel of either seamless or ERW type. All pipes and fittings shall be new, of approved manufacture and the right grades. Each length of pipe shall be thoroughly cleaned and blown out to remove all scale and dirt before erection. Rusting pipes and fittings and piping and fittings of classes other than specified will be rejected.

2.9.2 Pipe Work Joints and Fittings

Pipes of 50mm diameter and smaller shall be screw jointed. At dismantling points or where pipework is connected to an appliance (e.g. hose reel), ground-in spherical seated unions shall be used. All screw threads shall be made up to the full depth of the socket and shall be clean and square with the axis of the pipe bore. Only Teflon or equal approved PTFE sealing tape shall be used in jointing. Hemp or similar organic substances shall not be permitted. In all piping, bends shall be long radius bends with turning radii not less than five times the pipe diameters. If this cannot be achieved, alternative bends of approved type shall be used. Reduction in the diameter of through-flow pipes shall be by means of reduction sockets.

Eccentric reducing sockets shall be used on horizontal pipes and concentric reducing sockets on vertical pipes only.

Joints in pipe work 65mm and above shall be made with Victaulic grooved couplings or similar approved mechanical pipe couplings or welded pipe joints. If coupling is used, couplings shall be self-centering and engage and lock in place the grooved or shouldered pipe and pipe fitting ends in a positive watertight couple providing some allowance for angular pipe deflection, contraction and expansion. Coupling housing clamps shall place a composition water sealing ring so designed that the internal water pressure increases the water tightness of the seal. The coupling assembly shall securely hold together by two or more track head, square or oval neck, heat-treated carbon steel bolts and nuts requiring only a single spanner. All pipe fittings connected to mechanical pipe couplings shall have grooved or shouldered ends and shall be malleable iron castings. Flanged or threaded valves may be used with grooved adaptor. Before grooved couplings are assembled, pipe ends and seal rings shall be lubricated as recommended by the manufacturers, to facilitate installation. Pipe grooving and the entire coupling installation shall be in accordance with the pipe coupling manufacturer's specifications. Couplings and fittings shall be capable of withstanding a test pressure of 10 bar or 1.5 times the working pressure, whichever is greater.

2.9.3 Pipe Supports

Pipe work shall be supported to permit free movement due to expansion and contraction. Pipework supports shall be arranged as near as possible to joints and changes in direction, and each support shall take its due proportion of the load. The spacing of the supports shall be in conformity with the recommendations of the grooved coupling manufacturer but shall not exceed the centers given below. Where there are two or more pipes, the spacing shall be based on the centers required by the smallest bore pipework.

Size of Pipe (mm)	Intervals for Horizontal runs (m)	Intervals for Vertical runs (m)
20	2.4	3.0
25	2.4	3.0
32	2.4	3.7
40	2.4	3.7
50	2.4	3.7
65	3.0	4.6
80	3.0	4.6
100	3.0	5.5
125	3.7	5.5
150	4.5	5.5
200	6.0	8.5

Vertical rising pipework shall be supported at the base to withstand the total weight of the riser. Branches from riser shall not be used as a means of support for the riser. Brackets screwed to walls shall be secured by expanding plugs or other purpose designed fixing devices to suit the material of the wall (e.g. brick, concrete, hollow block etc.); Wooden or plastic plugs will not be permitted. Pipework of 65mm size and above subject to expansion and contraction and hung from supports shall be suspended on swivel hangers unless otherwise agreed with the Engineer. For horizontal pipelines, hangers shall be of split ring adjustable type hung on mild steel rods. Caliper hooks may not be used. Where pipelines run along walls, columns or ceilings, brackets may be used. A support should be installed not more than 600mm from each change of direction. Special care should be taken when making piping connections to equipment (e.g. pump set) to ensure that the connections are properly aligned and that no stresses and strains are imposed on the equipment.

2.9.4 Pipe Work – General

The whole of the installation, including all valves and fittings, should be satisfactory to the local fire authority. Before any work starts, plans showing details of the arrangements proposed shall be submitted to the fire authority and its approval obtained. The design and installation of the hydrant and hose-reel system shall be closely correlated with all other services being provided in the building. All fittings shall, as far as practicable, be the same size as the pipes connected to them. Bushed outlets will only be accepted if the required outlet size of a fitting is not standard manufacture. All changes in the direction of a run piping shall be made with standard bends, springs or long turn fittings. Elbows may be used with the concurrence of the Engineer where space restrictions do not permit the use of easy bends.

Pipes shall be removed after cutting and shall be thoroughly cleaned before erection. Open ends left during the progress of work shall be temporarily closed with purpose-made metal or plastic plugs of caps, or blank metal flanges. No pipe should be installed so as to cause unusual noise from the flow therein under normal operation.

Joints shall not be made in thickness of any wall, floor or ceiling or in any inaccessible space, and pipework shall not be embedded in the structure of floor unless otherwise instructed by the Engineer.

Where pipework passes through walls, floors or ceilings, sleeves shall be provided. Pipework passing through floors shall be provided with 3mm mild steel floor and ceiling plates fastened securely to the sleeve. Sleeves shall be formed from pipes of suitable larger diameter and the space between pipework and sleeves shall be plugged with an approved sealant, which will not cause hindrance to pipe expansion and contraction and will not run.

All piping shall generally be run parallel to the axes of the building, concealed in the false ceilings and ducting where possible, arranged to conform to the architectural and structural requirements and to suit the necessities of clearance for the work of other trades. The clearance between pipework and the wall and any other fixtures shall be not less than 25mm. The pipe work shall be graded to ensure venting and draining. Reinforced molded bellows expansion joints with integral flanges shall be incorporated into the suction line between the pump set and the sump to prevent the transmission of vibration to the sump connection. The joints shall adequately be restrained and supported in accordance with the manufacturer's recommendations.

2.10 Fittings and Accessories

2.10.1 Valves (except landing valves)

All valves and fittings shall conform to the relevant British and the Local By-laws, regulation and standards.

Except for control valves, pressure reducing valves and similar valves, which have been specifically sized for the duty concerned, all valves shall be of nominal size as the pipeline. Valves shall be installed in accessible positions, located as near as possible to supports and equipment. The connection between each valve and adjacent equipment or piping shall be of screwed connection.

Valves shall be installed in strict compliance with the manufacturer's recommendations. Every valve shall be blown out before installation to remove any foreign matter lodged in the valve.

- Isolating valves sized up to and including 2" (50mm) shall be of the gate type with bronze body, bronze solid wedge, rising stem and screwed bonnet being flanged to BS 10 or screwed to BS 10226 as applicable. Valves shall be complete with a locking facility.
- Balancing valves shall be globe or ball valves of approved pattern and manufacture. They shall be of bronze body for valve sizes above. Valves shall have bronze or brass-spindle, replaceable seats and steel hand wheels.
- Non-return valves sized up to and including 1 1/2" (40mm) shall be of the swing check type to BS 1953 with bronze bodies screwed bonnet and bronze metal to metal seat. The connections shall be flanged to BS 10 Table E or screwed as applicable.
- Non-return valves sized at 2" (50mm) and over shall be of the swing check type with cast iron body, cover plate and bronze metal to metal seat. The connections shall be flanged to BS 10. A vent cock shall be incorporated in the cover.
- Strainers of sizes up to 2 in. (50mm) diameter shall be bronze body strainers. Sizes 2 in. (50mm) and larger shall be cast iron body type fitted with removable bronze screens.
- Automatic air release valves with isolation valves shall be installed on all high points of piping whether shown on the drawings or not. They shall be of bronze body with brass ball, and stainless-steel valve and seat.

- Drain valves shall be fitted at the base of pipe risers, headers and all low points of the piping system. The valves shall be brass bib cocks with hose connections.
- Flexible Pipe Connectors -The Contractor is to supply and install flexible pipe connectors of minimum 450mm long at the pump suction and discharge of each pump. All the flexible pipe connectors are to have flanged ends and must be suitable for the conveying medium and testing pressure of the systems concerned.
- All valves shall be new and of approved manufacture or as approved. Samples of valves proposed for use shall be submitted for approval.
- All valves shall be placed in accessible positions for operation and repairs. The connections between each valve and adjacent piping or equipment shall be made either with a flange (65 mm dia. and above) or a union (up to 50mm dia).
- The valves and glands shall be designed to withstand without leaks, the system pressures whether the pumps are in operation or not.
- Each isolating valve shall be provided with a means for attaching a strap so that the hand wheel may be secured in any desired position to prevent unauthorized use.
- A purpose-made strap of leather or reinforced plastic material not less than 12mm wide nor less than 2mm thick and a small non-ferrous padlock to secure the two ends of the strap shall be supplied with each valve.
- Alternative means of securing the valves against unauthorized use may be offered.
- Straight pattern valves shall be of the full-way gate type.
- The bodies of valves up-to and including 50mm diameter shall be of cast gunmetal or bronze. Bodies of valves 65mm diameter and above shall be of cast iron. Casting shall be of good quality, clean and smooth and free from scale or falls.
- The system drain valves shall be 25 mm diameter, key operated type with hose unions fitted to the discharge end.

On suction of all pumps, the flexible connectors shall be: All stainless-steel construction externally braided, double flanged, flexible hose, one for each pump, full line size, rated 700 kPa minimum working pressure. Hose length to be chosen to give lateral movement of +/- 6mm.

On discharge of all pumps, the flexible connectors shall be: All stainless-steel construction externally braided, double flanged, flexible hose, one for each pump, full line size, rated 2,500 kPa minimum working pressure.

Pressure switches shall be of the electrically operated type and shall be selected to suit the system installed.

2.10.2 Air Vents

Automatic air vents shall be used at the top of each rise.

They shall have gunmetal or brass bodies, non-ferrous or stainless-steel floats and guides and non-corrodible valves and seats. An air outlet, tapped to accept a drain line should be provided.

A manual test cock shall be fitted to the automatic air vent so that it is possible to check the vent is not air bound due to the orifice being clogged and to enable manual venting should be automatic vent fail.

The automatic vent shall be isolated from the system with a gate valve to permit cleaning and repair if necessary.

Air release pipes shall be run to discharge at the nearest visible point to be agreed with the Engineer and where maintenance personal can regularly check for leakage.

2.10.3 Expansion Bends and Anchors

Any continuous straight pipe run in excess of 30 meters on one side of an anchor point shall be fitted with expansion bends or flexible connections.

2.10.4 Pressure Gauges

Pressure gauges 100mm dia. maximum, shall be installed in the following locations:

- (a) Top-most point of hose riser
- (c) In the positions shown in the drawings and where deemed necessary

The gauges shall be provided with a device to dampen pulsations and the fixing of the gauge shall be such that it may be removed and re-fitted without shutting down the line.

Pressure gauges shall conform to BS EN 837-1 and shall be minimum 4 in. (100mm) diameter dial type of approved pattern and manufacture. The scale value shall be calibrated up to 150% of the maximum known pressure. Gauge connections shall be complete with an isolating gauge cock as well as anti-vibration cork snubbers.

2.10.5 Shock Absorbers

Shock absorbers or water hammer arrestors shall be installed in the mains supply pipework, downstream from the pumps, whether or not shown on drawings. The Contractor shall ensure that the shock absorbers provided are suitable for the system and shall be sized to overcome water hammer and surge in the system due to abrupt pump stoppage especially during testing. Shock absorbers shall be of the permanently sealed, gas filled, non-mechanical type. Calculations for the sizing of the shock absorber shall be submitted for approval.

2.11 Installation

2.11.1 Pipework Installation

Provision shall be made in the piping system to compensate for expansion, contraction, settling and vibration. Supports shall be provided at each change of direction. Any continuous straight pipe run in excess of 30 meters on one side of an anchor point shall be fitted with expansion bends or flexible connections.

All piping shall be graded to ensure venting and all piping and fittings arranged so that the complete system can be thoroughly drained. Separate drain valves or drain plugs shall be installed for all piping that cannot be drained back to the piping main. Air locking shall be prevented by the use of air cocks fitted where necessary located for convenient operation.

All services shall be installed in an approved manner to meet the Structural and Architectural Conditions and to avoid interference as far as possible with the work of other trades.

Where pipework passes through building structures G.I. Pipe sleeve shall be provided, sized to give a minimum of 1/2" (15mm) gap full around the pipe. The length of sleeve is to suit the thickness of the structure. Where the pipes pass through steel beams a 1" (25mm) spacer shall be allowed between the sleeve and the reinforcing plate around the hole. This sleeve shall be packed with asbestos fire proofing compound in an approved manner.

All pipes passing vertically through floor shall have sleeves extending 1 in. (25mm) above the floor. All sleeves shall be supplied by the fire contractor and handed to the Building Contractor, together with detailed drawings showing exact locations required in sufficient time to avoid building delay.

Pipe supports and hangers shall be spaced at intervals not exceeding the values mentioned in the table under clause 2.10.3. The means of supporting and anchoring of hangers and brackets shall be approved by the Engineer before installation.

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 diameter 1 1/4 in (32mm).

A minimum of 2 in. (50mm) clearance shall be maintained between the pipe and the nearest wall or ceiling surface.

2.12 Portable Fire Extinguishers

2.12.1 General

Portable fire extinguishers shall be re-chargeable, metal-bodied type containing and extinguishing agent expelled by the action of internal pressure. They shall be manufactured to BS EN 3 or equivalent and approved by the local fire authority (MNDF).

The extinguisher shall be operated by piercing, opening and/or breaking a sealing device and thus releasing the contents. The method of operation shall be readily apparent. It shall not be necessary for any movement of the actuating mechanism or mechanisms to be repeated in order to initiate discharge of the extinguisher.

All portable Fire Extinguishers shall comply with BS Codes and extinguish shall be released by means of a lever-operated valve provided with a safety pin. The extinguisher shall be capable of controlled partial discharge.

All internal extinguishers shall be wall mounted and attached in a manner affording quick release from the supporting bracket. They shall be installed so that the top of the extinguisher is not more than 1500 mm above the floor and in no case shall the clearance between the bottom of the extinguishers and the floor be less than 100mm. The extinguishers shall be positioned so that the instructions for operation to face outward. The instructions for operations shall be written in English language.

The extinguishers shall be Colour Coded for easy identification and shall be fitted with a visual “discharged” indicator to prevent accidental use of an empty cylinder.

The quantity, types, sizes and locations of the extinguishers to be provided shall be in accordance with the drawings and Part II of the Specifications.

The following portable fire extinguishers shall be installed on the floors as shown in the drawings.

- 2 kg CO₂ fire extinguisher fully charged with metal bracket fixed on to the wall.
- 9 liter water CO₂ fire extinguisher fully charged with metal bracket fixed on to the wall.
- 6 kg dry powder fire extinguisher fully charged with metal bracket fixed on to the wall.

The Sub-contractor shall supply and install portable type fire extinguishers in the location as shown in the drawings.

The contractor shall be responsible for obtaining approval from the Local Fire Authority for all extinguishers installed. The approval fee required for this purpose shall be deemed to have been included in the tender price.

The words 'FIRE EXTINGUISHERS' shall be painted using luminous paint on the wall above where the fire extinguisher is installed.

Extinguishers shall be conspicuously located where they will be readily accessible and immediately available in the event of fire. They shall, in general, be located along normal paths of travel and not to be obstructed or obscured from view.

In locations where visual obstruction cannot be completely avoided, means shall be provided to indicate the location.

2.12.2 Mounting

Where fire cabinet is available Extinguishers shall be wall mounted and attached in a manner affording quick release from the Supporting bracket. They shall be installed so that the top of the extinguisher is not more than 1.5m above the floor and in no case shall the clearance between the bottom of the extinguishers and the floor is less than 1m. The extinguishers shall be positioned so that the instructions for operation face outward.

2.13 Testing and Commissioning

Upon completion of installation the contractor shall notify the Engineer and proceed to undertake the balancing, testing, calibration and setting of all equipment and controls. Notification shall not be less than 48 hours in advance of any testing to be done.

All components shall be systematically tested for correct operation to ensure an approved installation as follows:

- All pumps shall be checked for flow rates, pressure head and r.p.m.
- All pipework shall be hydrostatically tested to 10 bar or 1.5 times the working pressure whichever is greater. This shall be maintained for a period not less than 24 hours.
- All items shall be tested for leaks including canvas hoses.
- All pressure and flow switches shall be set and tested to the satisfaction of the Engineer.
- All control board circuitry, indicators and alarms shall be checked for correct setting and operation.
- The two highest or most hydraulically remote hose reels shall be discharged simultaneously and checked for discharge rates and cut-in and cut-off limits of the duty pump set.
- The three highest or most hydraulically remote landing valves shall be discharged simultaneously and checked for discharge rates.
- Pressure levels at each landing valve outlet and hose reels.
- Operation of all hose reels and landing valves.

If as a result of these tests any defects are found, these shall be remedied as necessary, and a retest of the system shall be carried out.

When the contractor is satisfied that the installation is complete, fully operational and meeting the requirements of the code, he shall notify the Engineer in writing for an appointment to inspect the works and to arrange for attendance by a representative of the Local Fire Authority to test and inspect the installation. The contractor shall prepare all necessary certificates certifying the installation as meeting with all the relevant requirements of the Local Fire Authority. Three copies of the completion and acceptance certificates shall be submitted.

2.14 Finishes

Valves, hose reels and similar manufactured item of plant and equipment shall be completely fitted and finished in the manufacturer's work. Any deterioration or damage to manufacturer's finishes during storage and installation shall be made good by the Contractor at his own expense, to the satisfaction of the Engineer. The surface of all ferrous metal work including pipework brackets, hangers, steelwork etc. Which are not protected by galvanizing, work applied primer or protective paint shall be cleaned to remove all grease and rust and then given one liberal coat of anti-corrosive red lead primer and finished with two coats of approved quality signal red enamel. Those parts of the installation required to be left unpainted (e.g. brass work) shall be so left. Direction of flow shall be adequately indicated on all pipework.

2.15 Fire Pump Room Civil Work

The drilling of suitable holes on the floor slab or water sump wall for suction pipes, construction of concrete plinths for fire pumps, etc. have to be carried out by the fire system contractor in coordination with the main civil contractor.

3 FIRE DETECTION SYSTEM

3.1 System Description

The building is provided with an addressable fire detection system. Fire Alarm control panel, two-way communication system equipment, personal computer and printer are provided in the Fire Command Centre provided in the building (24 hours monitoring facility) that can monitor the detection systems. The system is an addressable type of system which has capability to detect and identify exact location of the fault. Unique identification which is known as “address” can be assigned to each and every point. With the help of this address once any point is activated, the system has the capability to indicate the details such as location, type of device, the response at the panel.

Main components of the system are as follows.

1. Main Fire Alarm Control Panel (FACP): Control panel is located at the CCTV communication and control room
2. Fire Alarm Repeater Panel (FARP): Repeater panels are located at security points and reception
3. Smoke detectors: Smoke detectors are provided on the ceilings at lobbies and office areas, lift shafts, plant rooms, panel rooms, ceiling voids, etc.
4. Heat detectors: Heat detectors are placed at pantry areas, car parking areas etc.
5. Alarm sounders: Alarm sounders are in every lobby and all the enclosed areas.
6. Manual Call Points: Manual call points are provided at the start and end of escape routes in the building and where necessary.

Further the system has interface with the Air conditioning and ventilation system. In a situation of fire smoke control system has to be operated to prevent spreading of smoke.

The elevators and the fire detection system are interfaced with automatic recall system in order to bring the elevator to the ground in case of fire.

The server room and HVAC control room, which are equipped with Fire Suppression System, are automatically operated by the signal from the fire detection system. They are independent systems but provide indication on the fire alarm control panel of the building in case of fire in the respective areas.

Two-way communication system is provided to communicate with fire fighters in a situation of fire and interfaced with a public address system in order to send warning massagers to the affected areas.

A reliable wiring system is important as it confirms the satisfactory operation of devices. The recommended cable types in clause 17.3 in BS 5839: Part 1(1988) is used for wiring of devices. Floor to floor wiring is run through GI conduit laid along a vertical riser and wiring within the floor is run inside the ceiling gap through GI conduits. PVC conduits are also acceptable with necessary fire sealants within the ceiling voids. All conduits within the concrete slab should be PVC.

3.1.1 Fire resistant cables and conduits

The wiring and conduit system for the Fire Detection System shall be completely segregated from all other wiring systems and shall be in accordance with the IEE Regulations.

All wirings shall be enclosed in conduit run in the following manner,

- Wiring within false ceiling spaces and all other areas shall be PVC concealed conduits to be chased in wall cast in columns/ concrete slabs or clipped soffit as directed by the engineer.
- Wiring within riser ducts, electrical switch-rooms, substations and mechanical plant rooms shall be in surface mounted or hanged in G.I conduits.
- All vertical wiring inside the ceiling spaces shall be in G.I. or PVC conduits with necessary flexible fittings at both connection ends. Necessary fireproofing sealants shall be provided for PVC conduits.
- Cables dropping from the concrete slab to the false ceiling shall be drawn in flexible steel or PVC conduits not more than 1m in length.

The wiring shall be carried out with fire resistant cables complied with latest editions of BS 6387:2013, BS 7629-1:2008 and BS EN 50200.

Number and size of conductors shall be as recommended by the fire alarm system manufacturer, but not less than 1.5mm² for initiating device circuits and signaling line circuits, and 2.5 mm² for notification appliances circuits.

3.2 Introduction

This section includes the supply, installation, testing and commissioning of the addressable type fire detection and alarm notification required to form a complete, operative,

coordinated system for the building. Fire detection and alarm system shall include but not be limited to the following.

- Addressable Fire Alarm Control Panel
- Addressable Fire Alarm Repeater Panel
- Video display terminal with keyboard & printer
- Two-way communication system
- Alarm initiating devices
- Alarm notification through Public Address System
- Interface/control and monitor modules for controlling and monitoring of other services
- Power supply
- Stand-by battery and battery charger
- Wiring

Locations of the devices and quantities are as shown in the drawings, and all the equipment should be according to the Bills of Quantities and specified there of

The system shall be configured as an addressable system together with interface modules for the following:

- Shutting down all Air Handling units of air conditioning system
- Controlling of lifts
- Fire Hydrant System
- Public Address System

3.3 Scope of Work

The scope of work includes the following:

- Supply of all equipment and materials required for fire detection system and wiring to Public Address System for alarm notification.
- Provision of a microphone including wiring to public address system for the Fireman's use. Provide all required labor and installation of the complete system
- Preparation of shop drawings conforming to the requirements of local fire authority (MNDF) with any revisions required in layouts and points to conform to the requirements of the authority
- Testing and commissioning of the system and handing over after successful completion

- Obtaining certificate of conformity from local fire authority (MNDF) on completion of work.
- Submitting sets of As Built Approved Drawings together with Operation and Maintenance manuals and necessary software on completion of work.

3.4 General

All equipment and components shall be brand new, and of manufacturer's current models. The materials, appliances, equipment and devices shall be tested and listed by a nationally recognized approval agency for use as part of a protected premises protective signaling (fire alarm) system. All equipment and components shall be installed in strict compliance with each manufacturer's recommendations. Samples and manufacturer's technical literature shall be submitted for Engineer's approval before the installation. All samples shall be supplied by the Contractor at his own expenses,

The system shall be of the analogue addressable type with voice command feature, microprocessor based, audibly and visually supervised, with detection and alert devices distributed where dictated by Code. The life safety system shall be composed of three subsystems for fire detection and alarm annunciation, emergency voice/alarm, and two-way communication. The system should be zoned and non-coded.

The following measures shall be taken:

- Interface with other systems such as security and door access systems, firefighting, standby/emergency power supply, Audio Visual system, elevators, etc. shall be required,
- Standby emergency power supply system should be provided to ensure continuity of power supply to loads that are essential to life safety such as the fire alarm system, the CCTV communication and control room, the fire pumps and mechanical equipment used for smoke control procedures and at least one elevator in every bank with power transferable to any other elevator in the bank.
- A two-way telephone communication service is to be installed for fire fighters' use. This system shall operate between the central control room and every fire lobby, Pump rooms and Lift machine rooms. Notification of occupants shall be achieved through a voice communication system.

The basic system components shall be the following:

- Main Fire Alarm Control Panel (FACP), microprocessor based, addressable type, modular expandable, fully electronic, electrically supervised, divided into main compartments for control, annunciation and amplifiers. The system should have batteries capable of monitoring the system for 24 hours and then sounding the alarm for 30 minutes.
- Color graphics CRT terminal
- Wiring, between the speakers/horns, visual alert devices, emergency telephone, detectors, and control modules on one hand and the main control panel on the other hand, shall be via the sub fire alarm panels that have multiplexing features and amplifiers rated for the required audio load.
- Automatic and manual detectors consist of smoke, heat, and manual call point. Detectors shall be located according to spacing mentioned on relevant codes to cover the whole area.
- Alarm notification devices consisting of audible alarms (bells, speakers and horns) and visual alarms (strobe lights). The voice alarm system shall be capable of broadcasting pre-recorded messages and have an interface with the fire fighters' station at the main panel. The main fire alarm panel shall house the amplifiers sized in accordance with the number of speakers and wattage. Speakers shall have different tap settings and shall be adjusted on site for optimum performance and maximum coverage. Alert devices should be designed to ensure a sound level of 15 dB above ambient noise in each area.
- Fire fighter's communication system consisting of telephone handsets located next to the exits on each floor and in every elevator car and elevator lobby for high-rise structures.
- Interface with the Building Management System (if available), fire pumps and HVAC control and with other systems such as security, standby/emergency power supply, elevators, etc.
- Data Network: each Main and Sub fire alarm control panel is a node of a network with direct communications into the network but operates on a stand-alone basis. Although performing different functions, each Main Fire Alarm Control Panel serves as a "peer-to-peer" (equal) partner in controlling network communications. Network information is sequentially transmitted from one node to another.

The fire alarm system shall provide visual and audible warning on main annunciator panel for supervisory signals such as:

- Failure or disconnection of power supply to main control panel
- Failure of fuse or protective device
- Removal of detector head on any initiating circuit
- Break or short circuit in wiring of any initiating or alarm circuit
- Valve tamper at fire pumps
- Fire pumps running
- Fire pumps power loss
- Fire pumps phase reversal
- Fire pumps/Control panel operating on emergency power

Even though an addressable fire alarm system shall be installed, buildings shall still be divided into zones to identify the location of a fire to help reduce confusion. The following criteria shall be followed in the zoning:

- A single zone shall not exceed 2000m².
- A zone shall not cover more than one story.
- Stairwells and elevator shafts shall be treated as separate zones.
- The two-hour fire separations dictated by the architectural requirements shall be used as separate zones.

3.5 Applicable Standards

The work outlined in this section covers the supply of all materials, which shall be new and unused, equipment and labour necessary for the complete installation, testing and commissioning and handing over in approved working order of the complete system. It shall also be in accordance with the rules and regulations of the Local Fire Authority and of the following: -

All equipment and material used, and Fire Detection and Alarm System shall meet the requirements of the relevant standards / publications.

- British Standards Institution

Latest editions of BS EN 54 Fire detection and fire alarm systems

Latest editions of BS 5839 Fire detection and alarm systems for buildings

- All requirements of the local fire authority (MNDF) and Ministry of Defense and National Security

3.6 Equipment and Materials

All equipment and components shall be brand new, and of manufacturer's current models. The materials, appliances, equipment and devices shall be tested and listed by a nationally recognized approval agency for use as part of a protected premises protective signaling (fire alarm) system. All equipment and components shall be installed in strict compliance with each manufacturer's recommendations. Samples and manufacturer's technical literature shall be submitted for Engineer's approval before the installation. All samples shall be supplied by the Contractor at his own expenses.

3.7 Fire Alarm Control Panel

The Fire Alarm Control Panel shall provide addressable data communication circuit connections for communication with the addressable devices. Each addressable communication circuit shall provide the capability of communicating with a minimum of 150 addressable devices, or as per manufacture's standards. In order to permit future additions, no more than 80% of the addresses available on any single addressable data communication circuit shall be utilized. For the specified number of addressable devices, a 4 - loop (minimum) panel is suggested. The fire alarm control panel should be designed to continuously monitor and display the status of the system, giving location of a fire or fault and providing power to the entire detection and alarm system.

The control unit shall be housed in a heavy gauge metal cabinet designed for surface mounting. The cover shall be lockable to prevent unauthorized access. The operating controls and indicators shall be located behind the lockable door.

All detection and alarm indicator circuits shall be monitored against open/short circuit and earth faults. A malfunction in any device shall result in fault condition in that device or loop only, while other devices continue to operate normally. A fault shall be indicated by audible alarms; LED indicator and location of the fire or fault shall be indicated on the Fire Alarm Control Panel Liquid Crystal Display (LCD). On acceptance of a fault condition in the device, a subsequent fault in another device shall reactive the audible alarm and visual indication. There shall be a clear distinction between the fire and fault audible alarms.

Each fire alarm indicator shall be clearly indicated with the word "FIRE" on a red colour background, and each fault warning indicator shall be clearly labeled with the word "FAULT" on an amber color background.

The activation of the flow switch fitted at fire pump distribution line shall be indicated in the FACP.

In addition to that, provisions shall be made to send signals manually and automatically to fire man's lift and passenger lifts to activate the lifts to travel automatically, to ground floor, shut off the all air conditioning units and public-address system to activate fire alarm notification in case of a fire situation.

Upon loss of mains power, the power supply unit shall automatically revert to battery power. When the battery voltage drops below 20V a fault indication shall be provided to indicate the battery fault condition.

A visible and local audible signal shall be provided to indicate that the control unit is operating on emergency power. A mute switch shall be provided to cancel the audible signal upon acknowledgement.

When mains AC power is restored, the control unit shall automatically revert to normal operation without needing any manual switching procedure.

The entire power supply and charger circuits, including all fuses, shall be supervised. Any malfunction or blown or missing fuse shall result in a fault indication on the control unit. The control system shall incorporate a facility for and shall include a one-man inspection device. By plugging in this device to the control system, it shall be possible for one person to check the operation of the detectors by activating each detector in turn from the detector location. The one-man inspection device shall automatically reset the alarm system to normal after pre-set time interval once the alarm has been activated by the detector under test. The time interval shall be adjustable in steps up to about 30 seconds. Protection shall be provided for solid-state components against reversal of polarity of the battery supply.

The Main Fire Alarm Control Panel (FACP) shall be of the multiple processor based truly Analogue intelligent type, of modular architecture, being of the latest design and manufacture. The FACP shall be suitable for ambient conditions varying between 0°C to + 55°C, with relative humidity up to 95% non-condensing.

The FACP shall be manufactured to BS 5750 ISO 9000 quality standards, by an approved and well-known manufacturer who provides design, service back up, and spare parts locally.

The processor system shall as a minimum once per day at the set time automatically adjust all sensing devices to compensate for sensitivity increase due to environmental conditions. This check should also incorporate a full "Check sum" evaluation to detect unauthorized programming changes, or data corruption.

The control panel shall be capable of being extended in modules of 4 loops, up to a maximum of 6 loops. Each 4-loop module shall incorporate its own microprocessor and shall be electrically isolated from the main processor board. The loop board shall incorporate dc/dc converters to prevent loop cross talk. Each converter board shall be provided with step up voltage converter to ensure the correct line voltages are maintained to the detection loops in the event of mains power failure in combination with low battery state.

To increase fault finding capability each loop processor board shall have LED indicators.

It shall be possible to site a four-loop processor board remotely from the main control panel up to a maximum distance of 1000 meters and interconnect with the main panel via a four wire screened data line.

Each loop shall be capable of accepting as a minimum 150 Analogue addressable detectors or control devices. The loop PCB will incorporate "on board" short circuit isolators for both the incoming and outgoing loop wiring.

The system architecture and software will allow for random addressing of each device to suit field conditions, preset order or soft addressing will not be acceptable.

Each processor shall continuously monitor the Analogue signal from detectors and evaluate this signal against a pre-determined set of fire algorithms, to accurately determine the existence of fire and to reduce unwanted alarms.

There shall be no limit to the number of detectors per loop which can be in alarm simultaneously, the vacuum fluorescent display (VFD) shall be capable of reporting all incoming alarms by use of a scroll function. The scroll function shall be accessible at all times without the need for "key access".

The FACP shall incorporate as standard a vacuum fluorescent display module, which provides, for power conservation reasons, two levels of brightness output. Level 1 output will "low" for

standby conditions, with level two providing "high" output, to signal change of state or alarm processing.

The display shall provide up to two rows of 40 characters.

The FACP shall be able to incorporate an integral printer unit, which shall record all changes of state, alarms, faults and operator actions, overall, the minimum requirements will be: -

- list isolated devices
- list loop devices
- List of Event Log
- list panel outputs
- list loop outputs
- list loop output devices
- list check sums for (programming and EPROM error checking)
- list single device analogue value

The FACP shall be able to be expanded, to the following features.

- Repeat panel drive
- remote printer (ASCII expanded text)
- mimic driver
- 32/64/96 way programmable outputs
- BMS system RS 232 output
- Interfacing Facility

Interfacing Works to Future Fire Alarm Panels

The Fire Alarm System shall be designed to interface with future fire alarm panels with a maximum of 64 fire controllers on the Network.

The networks should be totally flexible and enable the fire controllers to be seamlessly linked together, providing a system capability of up to 160,000 detection addresses and over 14,000 digital I/O points.

The Fire Command Centre (FCC) shall be configured to monitor the status of all the fire controllers and transmit signals to the fire controllers for specific actions to be performed.

The system shall be able to incorporate the extension of the Fire Alarm Annunciator and Control Panel to provide remote start/stop of equipment such as fans, dampers etc.

3.8 Fire Alarm Software

The main processor shall incorporate a "Watchdog" system, which, in the event of processor failure will reboot the system in an attempt to correct the fault and return the system to full operation. Failure to reboot should result in a processor failure being announced both visually and audibly.

All software, program and data shall be held in non-volatile read only memories. System configuration data shall be stored in memory, which can be electrically erasable or alterable. This system shall be backed up by on board PCB rechargeable batteries with a life span of not less than 5 years. PCB battery should be continuously charged to ensure correct operation. Altered or reconfigured whilst in a live online situation. All configured data shall be able to be downloaded to the on-board printer for verification and checking purposes. Alarm processing should incorporate verification scanning before raising any fire or fault signals. The maximum permitted will be

3 Scans Fire

6 Scans Fault

A priority interrupt signal will be used for all manual break glass units, which will override the scanning process for fire indication.

The processor systems should include a software routine to enable pre alarm signals to be raised in the event of Analogue signal value from a detector reaching and maintaining a level of 80% of alarm threshold, after multiple scans.

All system configuration data shall be fully field programmable without exception and shall be able to be;

Non-Alarm Signals: The hardware and software shall be so configured as to allow for incoming "CHANGE OF STATE SIGNALS' Emanating from floor sprinkler control valve isolation including such signals as pump running. The control panel will process this as change of state only and not raise any executive actions or alarms. The internal printer will log such signals to hard print and also to the historical log function of the panel. All non-alarm signals shall be shown visually on the VFD and at the printer as "ALERT" signals only.

Walk Test Facility: A walk test facility shall be included which will allow for single man test and verification of loop or zone devices. This testing shall not at any time prevent a fire signal from being generated by devices on other loops or zones, which will automatically cancel the

test function and raise the normal executive actions of the fire system. It shall be possible to inhibit or have online during the test all field programmable outputs associated with the detectors in the zone or loop being tested.

Historical Event Log: The historical log shall have sufficient memory size to log and record up to 200 fire events or combinations or events including all operator actions taken. The details held within the log shall be capable of being downloaded to the fire alarm control panel integral printer.

3.9 Panel Hardware

The control panel cabinet shall be manufactured from sheet steel of not less than 1.5mm and be undercoated with corrosion resistant materials with final baked enamel paint finish.

Common master LED indication will be provided to give the following information: -

- General Fire
- Supply Healthy
- Pre alarm
- System Fault
- Device Fault
- External Fault
- Processor Fault
- Device Isolated
- Zone Indication

3.9.1 Vacuum Fluorescent Display Panel

The fire alarm control panel display will employ vacuum fluorescent, twin brightness level type display. The two levels of display brightness output will be Level One "Low" (Standby condition) Level "Two" high (Including alarms or panel in access, and operator action). The overall display will provide two-line output of up to 40 characters per line. The display will provide the following information.

- Device Type (non-abbreviated)
- Analogue Value
- Device Location
- Device address, zone number loop number

- Normal condition
- Access condition
- Fire alarm
- Device fault
- Pre-alarm
- Fault on loop
- External fault
- Control fault
- Alarm fault
- Supply fault
- Alarms sounded
- Alarms silenced
- Panel reset
- Maintenance mode
- Devices isolated
- Test mode

3.9.2 Master Alarm Board

The master alarm board shall provide as a minimum, the following common alarm and output facilities:

- Four sets changeover contacts (Two sets isolatable via on board switch).
- 4 alarm sounder monitored output lines rated at 1 amp each.
- Switch output for the following: -
 - Manual
 - Fault
 - Auxiliary
 - Buzzer
 - Alarm
- Ext. alarm
- A set of contact common/normal open will be provided which are delayed on power up and power down. This contact will be used for extinguishing system output to prevent spurious signals causing accidental operation of system.

- Visual indicators shall be provided to announce.
 - Alarm fault
 - Earth fault
 - Aux. 1 isolated

3.9.3 Operator Controls

The minimum operator control will be as follows: -

- Sound Alarms
- Silence Alarm
- System Reset
- Scroll Alarms

Access to the operator control must only be achieved by, authorized personnel and will only be accessible via a key "ACCESS" switch. Alarm scroll to be available at all times without the need for "Key Access".

A 12-way keypad touch sensitive membrane will be provided, providing three levels of users control, level two and three only be accessible on successful entry of a pass number code. The levels will provide the following.

Level 1 (Accessible by key switch operation)

- isolate/de-isolate device
- Set date and time
- List loop devices
- Select test mode
- LED test
- Enable / Disable printer.

Level 2 (Assessable by 4-digit code when in level 1) Facilities

- Print event log
- Read a single device
- List isolated devices (d) Program outputs
- Display checksums

Level 3 (Only available from level two) Facilities

- Print panel outputs
- Print loop devices

- Print loop outputs
- Programming

Level two and three shall be extended, when a handheld or portable computer is connected to allow for down-loading/uploading and programming of loop outputs, loop devices and panel outputs. The facilities required from the extended facility will be.

LEVEL 2	LEVEL 3
Message handler	Program panel output
Program loop devices	
Program loop outputs	
Load/Save program data	
Clear output	

3.9.4 Loop and Field Devices

Loop General:

The 'loop' shall be a two-wire circuit starting and returning at the two associated loop return input terminals of the control.

The loop shall be capable of driving as a minimum up to 150 field Analogue Addressable devices offer a maximum total loop distance of 2 kms.

Loop Communications:

The communication to and from each device shall be based on pulse position modulation digitally encoded on the power voltage.

Device Addressing:

There shall be no preset order for addressing the devices. The devices shall be addressed in an order appropriate to site conditions. This order will be determined during commissioning and the control panel will have the facility to override the address order to re-check any device showing a tendency to the alarm condition.

Loop Short Circuit Isolators:

Isolators should be fitted at a maximum spacing of one per 20 devices, or to suit local maximum zone size regulations. The isolators shall protect against short circuits on the loop by isolating

that section of the loop where the short circuit occurred, thus maintaining the integrity of the remainder of the system.

Short circuit isolators will be powered by loop wiring, and will be limited to 10 per loop.

Loop Interface Equipment:

The loop shall be of receiving information in addition to that from heat and smoke detectors e.g. operation of sprinkler system. The source of this information shall be identified by its own inquire address. Any interface equipment used to achieve this requirement shall be from the standard product range of the same manufacturer as the smoke and heat detectors provided for the loop.

Loop Power:

The loop wiring shall power the detectors, address, and carry data to any from the field devices by digitally encoded signals superimposed on the power voltage.

Automatic Devices Identification:

The control panel shall be able to identify what type of device is located at each address in order to protect against accidental fitting of an inappropriate sensor.

3.10 Detector Common Requirements

Detector Power:

The detectors shall be suitable for connecting to a two-wire 24V central system and operate satisfactorily within the supply voltage range of 17V-28V DC.

Detector Alarm Indication:

An indicator LED shall be provided on the detector, which illuminates when the detector has reached a pre-set alarm level. The indicator shall be operated independently of the detector, by a signal command from the central control panel.

Detector Remote Output:

Provisions shall be made for an output from the detector suitable for operating a remote indicator or other device with a current limitation of 4 milli-amps. This output will be initiated by a signal command from the control panel.

Detector Mounting Bases:

Separate mounting bases shall be required which shall be common in design for all types of detectors to be used. Bases shall enable ready removal of the detectors for maintenance. The bases shall be fitted with stainless steel terminal springs and stainless-steel terminal screw saddles; detector removal will not initiate an open circuit alarm. No detector base shall incorporate electronics of any type.

Detector Construction:

The construction of the detector and bases shall be in white self-extinguishing polycarbonate plastic. Full circuitry must be protected against moisture and fungus. Smoke entry points will be protected against dust and insect ingress by corrosion resistant gauze. The detectors must be unobtrusive when installed, having a dimension not exceeding 50mm x 100mm diameter maximum, including the mounting base. The detector shall be supplied complete, fully tested and factory pre calibrated.

Detector Addressing Method:

The unique address of the detector shall be set by the installer by means of a pre coded rigid plug-in card, which when fully inserted into the detector base will program the detector address. The coded card when fully inserted will protrude from the detector base, this section of the card will show a pre numbered label for ease of detector identification.

When the address code is set by means of a DIL switch it shall be obscured from sight by means of suitable label. The label shall indicate the relative positions of the DIL switch.

For all detectors with DIL addressing there shall be facility on the mounting base for writing in indelible ink the address of the base. The address code shall be obscured from sight when the detector is fitted to the base.

Detector Contamination:

The build-up of dirty or similar contamination on the radioactive or optical source will cause the output signal from the detector to gradually change. The control panel shall be capable of monitoring this slow change in signal and at a predetermined level indicate that the detector is in need of servicing, or as a minimum false a pre alarm.

Approvals:

All detectors shall have the relevant manufacturing certificates and be accepted for use by the local fire authority (MNDF).

3.11 Detection Devices

All analogue addressable field devices shall have an integral microprocessor on board. All these devices shall be BS EN 54/LPCB or UL/FM listed. These devices shall include, but not be limited to multisensory detectors, smoke and heat detectors, interface modules and gas releasing and suppression modules.

Addressable Intelligent Detectors:

Each intelligent smoke detector should be capable of transmitting pre-alarm and alarm signals in addition to the normal, trouble and need cleaning information. It shall be possible to program control panel activity to each level. Each detector may be individually programmed to operate at any one of five (5) sensitivity settings.

Each detector shall automatically change to standalone conventional device operation in the event of a loop controller communications failure. In the standalone detector mode, the detector shall continue to operate using sensitivity and environmental compensation information stored in its microprocessor at the time of communications failure. The FACP should monitor the loop and activate a loop alarm if any detector reaches its alarm sensitivity threshold.

Every intelligent detector shall be tested periodically for its sensitivity to ensure that the detector continues to operate accurately within its calibrated sensitivity windows. The detector shall be capable of performing independent check on its sensitivity window and should its sensitivity drift outside this window a fault message shall be reported automatically to the FACP. System offering this type of feature shall be supported with documents from an independent testing authority such as Underwriters Laboratory (UL) or Loss Prevention Council (LPCB).

All detectors must be immune to external Electro-Magnetic Interference conforming to IEC1000-4-8:1995 and ENV 50149:1995/ EN 500082-2:1995 and ENV 50140:1993/ EN 50082-2: 1995.

Electronic Horn/Strobe:

All electronic horn/strobes shall be provided according to the drawings.

The horn/strobe shall have a red plastic housing, ultra slim, protruding from the wall less than one inch from the wall. It should have an attractive appearance with no visible mounting screws. It shall fit all standard one-gang electrical boxes with plenty of room behind the signal for extra wire.

A sound output level of 91 dBA average shall be provided.

The strobe shall provide 15 cd or 15/75 cd or 30 cd or 110 cd synchronized flash outputs. The strobe shall have lens markings oriented for wall or ceiling mounting. It shall be possible to replace the lens markings with lens marking kits. Ceiling mounted strobes shall have lens markings with correctly oriented lettering. Removal of an installed Horn/Strobe to change the lens markings shall not be acceptable.

Horn/strobe shall mount to a masonry electrical box (2-1/2" deep)

A delay timer with adjustment from 0 to 5 minutes to set off the building alarm bells after a predetermined delay shall be provided. A manual switch should also be provided to give an immediate alarm.

General:

Average ambient sound levels greater than 105 dBA require visible notification appliances. Total sound pressure levels produced by ambient sound pressure levels and all operating audible notification appliances must not exceed 120 dBA within the occupied area.

Public areas:

In Public areas signals must have a sound level of at least 15 dB above the average ambient sound level or 5 dB above the maximum sound level having a duration of at least 60 seconds, whichever is greater. Measurements must be taken with an A-weighted scale (dBA) at 5 feet above the floor in occupied areas.

3.12 Automatic Fire Detectors

The following types of automatic fire detectors shall be provided, as appropriate to the location as indicated in the drawings.

- Photoelectric type Smoke detector - Addressable
- Heat detectors - Addressable

All the above detectors shall be of point type suitable for surface mounting. Smoke and Heat detectors shall be provided with an LED. LED shall flash under normal conditions, indicating that the detector is operational and in regular communication with the control panel and LED shall be placed into steady illumination by the control panel, indicating that

an alarm condition has been detected.

The detectors shall be ceiling or slab mounted and shall include a separate twist-lock base which includes a tamper proof feature.

The detectors shall provide a test which means whereby they will simulate an alarm condition and report that condition to the control panel. Such a test may be initiated at the detector itself (by activating a Magnetic switch) or initiated remotely on command from the control panel.

3.12.1 Smoke Detectors - Photoelectric Type (Addressable)

The photoelectric smoke detector shall operate on the principle of smoke detection by light scatter and shall have no moving parts of components subject to wear.

The electronic circuits shall be of the solid-state type and hermetically sealed to prevent disturbances due to dust, dirt or humidity. They shall further be protected against electrical transients and electromagnetic interference and shall not be damaged from reversed polarity or faulty zone wiring.

The design of the detector should be such that, to suppress false alarms due to deceptive transient phenomena (e.g. Vibration, humidity, dirt, etc.). It shall automatically compensate for the environmental conditions.

It shall be possible to test the sensitivity of a detector in the field. The response sensitivity shall be field adjustable to a minimum of two predetermined, factory calibrated levels.

A wire mesh shall be fitted to the detector windows to prevent the entry of insects into the Measuring Chamber.

The detector shall be complete with the mounting base, and it shall be capable of being installed into the base by a simple push-twist movement.

The colour of the detector should be off-white. The detector shall be able to reset from the central control panel.

3.12.2 Heat Detectors (Addressable)

The heat detectors shall be of combined rate-of-rise and fixed temperature type or as per the requirements mentioned in the BOQ.

The detectors shall incorporate a thermistor or thermistors, depending upon the type, to

detect the fixed temperature level, and the rate of temperature rise, working in conjunction with solid state electronic circuits, which shall be hermetically sealed to prevent disturbance by dust, dirt or humidity.

The circuitry shall be protected against electrical transients and electromagnetic interference and no detector shall be capable of being damaged from reversed polarity or faulty zone wiring.

The detector shall have no moving parts or components subject to wear. It shall be possible to test the sensitivity of a detector in the field. The combination type detector shall respond to a temperature rise at the rate of 10°C per minute and to temperatures exceeding 60°C.

The detector should be an off-white colour and capable of being reset from the main control panel.

The heat detector should be electronic in operation and suitable for connecting to a two-wire 24V central system, which can operate within the voltage range of 17V - 28V DC. Detector coverage will be 50m² at a height of up to 9m.

The device should monitor ambient temperature by means of an NTC thermistor. The detector shall be capable of operating within the following environmental limits.

Temperature operating range - 20°C to +60°C (no icing)

Humidity operating range 0% to 95% RH.

(Non-condensing) Wind - effected

3.14 Manual Call Points or Break-Glass Stations (Addressable)

The manual call points shall be electrically compatible with the automatic detectors. Manual call points shall be of the break-glass type in a shatter-proof, corrosion resistant housing of pleasant, streamlining Appearance.

All inscriptions, texts (which shall be in English) and markings shall be on the front plate of the manual call point or behind the glass and not on the glass, so that the glass may be easily replaced. The cover must be secured against unauthorized removal. Every removal of the cover shall release the alarm.

The alarm contacts shall be self-cleaning design to prevent failure after a prolonged period of inactivity in unclean environments. It shall be possible to test the call point without breaking the glass. It shall use a key operated test-reset lock and shall be designed so that

after actual emergency operation, it cannot be restored to normal use except by the use of a key. All operated stations shall have a positive, visual indication of operation and utilize a key type of reset. The exterior finish shall be in standard signal red.

3.14 Interface Module Common Requirements

Each interface unit for switch monitoring or output will have DIL switched to set the address and will be of the same protocol and manufacture. As the detection devices, all interface modules will be supplied complete with LED indicators, which shall illuminate on the operation of the interface device.

3.14.1 Monitor Modules

Monitor modules shall be provided to allow conventional to analogue connection for such devices as sprinkler flow switches, floor valve isolation (if applicable) or any such clean contact device as could be deemed necessary for inclusion within the fire system. The monitor module shall be capable of receiving contact configurations of normally open or closed loop. All monitor modules will be powered by loop wiring without the need for external power source.

3.14.2 Control Modules

Control modules will be provided for the connection to such items as pump start control, lift homing control, or local HVAC shut down, etc. As a standard each control module will cooperate with a set of changes and offer contacts to interface with the required service. The control module shall be capable of being programmed at the control panel to allow for operation by any device on any loop. A separate 24-volt dc input will be required for the input output modules. This supply must be derived from a monitored source and is battery backed up.

3.14.3 Sounder Circuit Controllers

Analogue addressable sounder circuit controllers shall be required; each unit shall have a unique address and be completely programmable from the fire alarm control panel. Each unit shall have a minimum output of 750 milli-amps. The addressing and switching power supply for the controller will be derived from the loop supply. However, the unit shall require a 24V DC supply to power the connected alarm load. This supply must be derived from a monitored source and be battery backed up.

3.14.4 Exit Signs

- Exit signs shall be provided at all exits, emergency exits and escape routes, in such a way that the position of any exit or route to it is easily located and followed.
- Exit signs shall be powered by a source independent of normal lighting and be installed so that in failure of normal power supply, emergency supply shall be capable of maintaining the illuminations of the sign.
- "EXIT" symbols in white on green background shall be placed above or close to doors and opening. Directional signs indicating the route to be followed should be placed wherever applicable.
- The set of batteries used when charged by its built-in chargers for a period of 2 hours to fully discharged condition shall have sufficient power to illuminate the EXIT sign for 3 hours without main power supply.

3.14.5 Emergency Lighting (shall be covered under Electrical work scope)

- Emergency lighting systems shall be provided to indicate clearly and unambiguously the escape routes and ensures that fire alarm call points and firefighting equipment provided along escape routes can be readily located.
- It shall be automatic in operation and shall provide sufficient illumination without undue delay for safe evacuation of the occupants in all areas of the building where it is required.

3.15 Fire Command Center (at CCTV communication and control room)

The fire protection subcontractor shall provide integrated panels/cabinets that can house the following facilities: -

- Main Fire Alarm Control Panel
- The control console of the voice communication system
- A fire alarm sounding device
- A repeater panel of the lifts position indicator board and lift intercom handset (by Lifts Subcontractor).
- Status indicator for all firefighting pumps and water tank.
- Status indicator for emergency generator (by Electrical Subcontractor).

- A telephone connected directly to the external exchange (by Electrical or ELV Subcontractor).
- A switch to isolate background music where required (by Electrical or ELV Subcontractor).
- A switch for silencing the fire alarm sounders in the building when the voice communication system is in use. (Note: The fire alarm sounders shall operate continuously for one minute after the initiation of an alarm signal before this silencing switch can be effective). This silencing switch shall be separate from the silencing switch at the main fire alarm panel for the purpose of isolating the alarm sounders during routine testing and maintenance.
- Building Management System, if available (by BMS subcontractor) including PCs, monitors, printers and UPS.
- Security System (by Electrical or ELV subcontractor) including PCs, monitors, VCRs, printers, batteries.
- CCTV Monitoring System including PCs, Monitors and UPS

The Fire Protection sub-contractor shall liaise with the respective subcontractors through Main Contractor for the dimensions and interface requirements. All the equipment shall be neatly mounted. Assume full responsibility for the co-ordination and submit complete shop drawing with all the above details. All brackets, openings, fixings, edging and facings are included in this Fire Protection Subcontract. All printers shall be mounted at an easily-accessible location above the desk-top.

All panels/consolas shall be fabricated of metal with finishes to Architect's approval. The work bench shall run the full length of the consoles and shall be at least 450mm wide.

The entire consoles and work benches shall be designed and constructed to be sturdy and resistant to wear, suitable for its foreseeable use.

3.16 Video Display Terminal

The standard personnel computer with Windows OS shall be able to be linked to the Fire Alarm Control Panel in order to download program and to take the system information and event list.

3.17 Standby Power Supply Equipment

The overall fire alarm system will be complete with a 24V D.C charger unit completed with sealed lead acid maintenance free batteries. The charging equipment will be of the approved type and be calculated in size to provide full standby back-up load for a period of not less than 24hrs with a full alarm, load for a minimum period of 2 hrs. The battery and charger unit will be supplied in a sheet steel lockable cabinet of the same construction and finish as the main fire alarm control panel.

The main power supply of 230V, 50Hz shall be provided to the Fire Command Centre according to the requirement of the manufacture. This supply shall be exclusive to the detection and alarm system and shall not be used for other purposes.

It shall provide all the necessary internal operating power for the FACP and power for operation of external alarm notification appliance circuits. It shall include a battery and charger system with a capacity for providing 24 hours of standby power using dual-rate charging techniques for slow and fast battery recharging. The incoming supply shall be controlled by an MCB, painted red and marked with the words "Fire Alarm System Do Not Switch Off" and normally padlocked in the "On" position. Suitable over voltage protection to prevent any malfunction or damage due to line surges shall be provided.

The battery shall be of the sealed lead acid type of 24V (nominal). When fully charged with the float charger inoperative, the battery shall be capable of maintaining the detection and alarm system in the non-alarm state for 24 hours and there after actuate all the alarm sounders continuously for half an hour. The performance and construction, of the float charger shall be in accordance with BS EN 54. It shall provide meters to indicate battery voltage and charging current.

3.18 Battery

Maintenance free sealed lead-acid batteries shall provide emergency power. Battery should have sufficient capacity to power the fire alarm system for not less than twenty-four hours plus 30 minutes of alarm during a mains power failure.

3.19 Battery Charger

Battery charger shall be fully automatic, with constant potential charger maintaining the battery fully charged under all service conditions. Charger shall operate from a 230V, 50 Hz single-phase. It shall be capable of fully charging a completely discharged battery

within 48 hours while supplying any loads connected to the battery simultaneously.

It should have protection to prevent discharge through the charger and for overloads and short circuits on both AC and DC sides.

3.19.1 Battery Calculations

The full alarm load will be calculated for a period of two hours to ensure the battery terminal voltage is sufficient not to cause permanent damage to the battery cells. The charger output should be sufficient to run the full alarm load of the system in the event of battery failure. The output shall also be of sufficient capacity to run the full standby load of the system and fully recharge the battery within a 48-hour period.

3.20 Wiring

Wiring shall be in accordance with the latest edition of IEE Wiring Regulation and as recommended by the manufacturer of the fire alarm system. Number and size of conductors shall be as recommended by the fire alarm system manufacturer, but not less than 1.5mm².

Wires shall be fire resistance type with the fire resistance capability of at least 0.5hr.

All field wiring shall be completely supervised. In the event of a primary power failure, disconnected standby battery, removal of any internal modules, or any open circuits in the field wiring; a trouble signal shall be activated until the system and its associated field wiring is restored to normal condition.

Loop cables should be run separately of all other services including alarm power circuits for alarm outputs.

The minimum permitted core size will be 1.5mm². For loop lengths of up to 1000 meters, 2.5mm² will be used for 1000 meters to 2000 meters lengths.

Cable Terminations:

All cable terminations at detectors and break glass devices will use spade type crimp connectors; all devices, which have standard enclosed terminal blocks, will use crimp pins for final termination.

Cable Markers:

All cable cores will be identified using ferrules to provide numbering and symbols as required.

Spare Capacity:

Each loop will populate to 80% capacity, providing 20% spare for future expansion and or change of use.

Hard Copy Program:

The successful contractor shall supply hard copies of all text programming information, including all input to output configurations for approval.

Documentation:

The successful equipment supply vendor will supply in duplicate the following documentation.

- Control Panel Manual - General Specification
- Control Panel Manual - Functional Description
- Control Panel Manual - Operating Instructions
- Control Panel Manual - Installation, Commissioning and Maintenance Instructions
- Field Device Manual
- Field Device Connection Details
- Control Panel Connection Details
- Add-on PCB Technical Information
- Literature All Items
- 2 years Spares Holding and Price

3.21 Installation

3.21.1 General

Installation shall be in accordance with the applicable standards, as shown on the drawings, and as recommended by the major equipment manufacturer.

3.21.2 Fire Alarm Control Panel

Fire alarm control panel shall be surface mounted on a steel cabinet in the central monitoring location (CCTV communication and control room) at Basement level.

3.21.3 Detectors

The locations of detectors, as shown in the drawings, are approximate. The Contractor shall adhere strictly to the manufacturer's installation instructions when deciding the final locations and the method of installation. Special emphasis shall be laid on achieving prescribed minimum distances between detectors, and from structural beams, walls, ceilings, etc. to the detectors. Fire detectors shall be surface mounted underneath ceilings and soffit. Remote indicators should be provided for all detectors installed within the ceiling voids as indicated in the drawings.

3.21.4 Manual Call Points

Manual Call Stations shall be suitable for surface mounting or semi-flush mounting and shall be installed approximately 1.2m above the finished floor. The locations of Manual Call Points on the drawings are approximate.

3.22 Voice Communication System

3.22.1 Two Way Communication System

Two-way communication system shall be provided to allow the caller to communicate both ways between the Fire Command Centre, fire pump room, fire lobbies on each floor level, lift machine rooms and chiller plant room. The two-way communication system shall be independent of all other communication systems within the building, and it consists of a control unit with a master handset located at central monitoring room (CCTV communication and control room).

3.22.2 Telephone Handset Jack

Emergency telephone handset jacks shall be flush mounted on stainless steel plates and located as in the drawings. Jacks shall be approved for emergency telephone system application. Insertion of a portable handset plug into a jack shall send a signal to the Central monitoring station (CCTV communication and control room), which shall audibly and visually indicate the on-line condition, and shall sound a "ring" indication in the handset. The two-way emergency telephone system shall support a minimum of five handsets online without degradation of the signal.

3.22.3 Emergency Telephone Handset

The telephone cabinet shall contain a minimum of five handsets, painted red and clearly labeled as "Emergency Telephone." The cabinet shall be located in the Central monitoring station (CCTV communication and control room), as shown on the drawings. On activating the remote phone, the phone earpiece shall sound a telephone ring signal until the master handset is lifted.

3.23 Tender Stage Documentation

Tenderer shall adequately and accurately describe the proposed system and concepts at the time of tendering, supported by a full set of drawings, specifications and catalogues describing the various components belonging to the fire detection and alarm system. Sufficient information, clearly presented, shall be included to determine compliance with specified requirements as indicated in drawings and specifications. Manufacturer's name(s), model numbers, ratings, power requirements, equipment layout, and device arrangement shall be included.

3.24 Contract Stage Documentation

The Contractor shall provide a full set of documents in duplicate, related to concept, design, installation, commissioning and the maintenance of the entire system and its components. The following sets of documents are required as a minimum per system component:

- System description and operating principle Installation instructions
- Connection Diagrams Commissioning Instructions Operating instructions
- Detailed maintenance instructions and trouble-shooting guide

The following drawings in detail are required as a minimum:

- System block diagrams wiring diagrams
- Plans showing detector locations
- Termination diagrams
- General arrangement plans, layout and outline drawings of system components. Position plans and sectional installation details

On completion of the installation and commissioning activities, the documentation shall be revised to incorporate any changes from the original and the final 'As-built' documentation

together with operation and maintenance manuals shall be submitted in triplicate to the Engineer by the contractor.

3.25 Testing and Commissioning

The Contractor shall provide all instruments and equipment together with commissioning Engineers and adequate assistance for carrying out the commissioning and testing activity, which shall be done in accordance with the applicable standards.

The commissioning and testing activity shall demonstrate that all equipment provided complies with the Specification in all particulars and that; they have been properly and completely installed. As a minimum the following tests shall be carried out.

- (a) Before energizing the cables and wires, check for correct connections and test for short circuit, ground faults, continuity, and insulation.
- (b) Open initiating device circuits and verify that the trouble signal actuates.
- (c) Open signaling line circuits and verify that the trouble signal actuates.
- (d) Open and short-circuit notification appliance circuits and verify that trouble signal
- (e) Ground initiating device circuits and verify response of trouble signals.
- (f) Ground signaling line circuits and verify response of trouble signals.
- (g) Ground notification appliance circuits and verify response of trouble signals.
- (h) Check installation, supervision, and operation of all detectors and manual call points.
- (i) Each of the alarm conditions that the system is required to detect should be introduced on the system. Verify the proper receipt and the proper processing of the signal at the FACP and the correct activation of the control points.

If any portion of the work fails to pass the tests, the Contractor shall, at his own expense, carry out such alterations or replacements as required to the satisfaction of the Engineer. The Engineer shall be at liberty to call for further commissioning when such alterations have been completed to their satisfaction. On satisfactory completion of the commissioning and testing activity, Contractor shall provide all necessary reports and records in triplicate set out to a format to be agreed with the Engineer. The Contractor shall provide commissioning spares in sufficient quantities at his own expense. Spare parts earmarked for maintenance shall not be used during this period.

4 Co-ordination and Integration with other services

Fire Contractor shall co-ordinate with the BMS (if available), AC and Lifts contactors to integrate the smoke management system and lifts installation. as per the specifications, point schedules, BOQs and Drawings.

5 List of Recommended Manufacturers

Item	Manufacturer/Brand Name	Country of origin and manufacture
Fire Pumps	KSB	UK
	Pentair	USA
	Grundfos	Denmark
	MasDaf	Turkey
	OR EQUIVALENT	
Hose reels and hydrant system accessories	Kolling	Malaysia
	SRI	Malaysia
	Eversafe	Malaysia
	OR EQUIVALENT	
Valves & Accessories	Pegler	UK
	Kitz	Japan
	Ayvaz	Turkey
	VIR	Italy
	OR EQUIVALENT	
GI Pipes	Surya	India
	Jindal	
	Hunan	China
	Mech	
	OR EQUIVALENT	
Detection System	Cooper by Eaton	UK
	Siemens	USA
	Simplex	USA
	OR EQUIVALENT	
Fire Rated Cables (MNDF Approval needs to be obtained)	2M Kablo	Turkey
	Wilson	Singapore
	OR EQUIVALENT	

6 Fire Suppression Systems

6.1 Server room and HVAC control room

A fire suppression system for the server room and HVAC control room shall be provided and installed as per the requirements of client/consultants. A suitable fire suppression system such as clean agent gaseous fire suppression system or Inert gas fire suppression system shall be proposed. The proposed system should be complied with relevant NFPA standards, and all equipment should be UL listed; FM approved or LPCB approved (subjected to Engineer's/Client's approval). Relevant documents as proof of certifications shall be submitted with the bid. The fire detection system for the actuation of the suppression system is to be a stand-alone detection system with a control panel, cross wired loops and detectors in accordance with NFPA standards. The dedicated detection system shall act separately from the central detection system of the premises except the status of the system shall be indicated through the FACP of the detection system. It should also be indicated on the BMS (if available). The contractor shall decide the system size, discharge times, discharge pressure etc. by a detailed design and the appropriate location for the cylinder bank shall be decided by the contractor upon the size and number of required cylinders. Detailed calculations shall be submitted for Engineer's approval before proceeding the procurement. Fire suppression system design shall be approved by the Fire Services Department.

The system shall comprise the following items, but shall not be limited to stipulated items;

- Control panel, Manifold, Pressure reducing units, Nozzles, Smoke/heat detectors, Alarm bells, Strobe Lights, Manual call points, Pressure gauges, Pressure relief flap, cylinder manifold with master and slave cylinders

The system shall be incorporated with dedicated early warning detection and alarm to facilitate confirmation of an incipient fire before release of agent.

All distribution piping shall be Schedule 40 seamless galvanized steel pipe to ASTM A106 Grade B or Stainless-steel pipes.

4. TECHNICAL SPECIFICATION OF ELECTRICAL SERVICES

4 Low Voltage System

4.1 General Conditions

4.1.1 Scope of Work

The Contractor shall carry out the supply, delivery, erection, connection, testing and commissioning of all the equipment and material for the complete Electrical Power Distribution, Wiring and Lighting System of the premises. The installation shall include but not necessarily be limited to the following:

- ✓ Obtaining Power supply from utility power supplier
- ✓ Generator back up power system
- ✓ Capacitor bank
- ✓ Uninterruptable Power Supply (UPS)
- ✓ Automatic Transfer Switch Panel
- ✓ Main distribution board
- ✓ Distribution boards and Consumer Units
- ✓ Lightning Protection System and Earthing system
- ✓ Final circuits from sub distribution boards / consumer units
- ✓ Lighting system – Indoor and Outdoor
- ✓ Small power installation comprising power socket outlets
- ✓ Cables and cable management system

4.1.2 General

Requirements Material

All the metallic components including equipment, fittings, enclosures and other accessories shall be protected with a protective paint coating or to be fabricated with any other applicable material (to the approval of the Engineer) in order to resist for the salty environment.

All materials and equipment shall be complying with the relevant British IEE Standard or IEC/ISO Standards and local Codes of Practice Associated Works

Some works and/or provisions associated with this sub-contract will be performed by others as indicated below:

4.1.2.1 Mechanical Contractor

Cable end will be provided for secondary electrical control panels by electrical contractor. required secondary electrical wiring, control wiring will be provided by mechanical contractor.

4.1.2.2 Plumbing Contractor

Cable end will be provided for secondary electrical control panels by electrical contractor. required secondary electrical wiring, control wiring will be provided by plumbing contractor.

4.1.2.3 Fire Contractor

Cable end will be provided for secondary electrical control panels by electrical contractor. required secondary electrical wiring, control wiring will be provided by fire contractor.

4.1.2.4 Generator contractor

Supply, Installation, testing and commissioning of generator system balance works up to AMF panel will be done by Generator contractor.

4.1.2.5 Building Management System

Electrical contractor shall provide the relays, contractors, breaker, selector switches, 230/24-volt transformers etc, in the distribution boards as required in BMS.

4.1.2.6 ELV

Required power provisions will be provided by electrical contractor.

4.1.2.7 Description of the Building

Twelve story office building consists of basement floor for parking, ground floor for parking, entrance lobby and other utility services, first floor for office and day care, second floor for cold rooms, third floor for warehouse, fourth floor to seventh floor for offices, meeting rooms and conference rooms, eighth floor for auditorium, roof terrace and lift machine room. The proposed cold chain facility building located at Hulhumale, Maldives.

4.1.3 Samples and Shop drawings

Samples and/or drawings shall

- be submitted to the Engineer in the format as specified.
- Include but not be limited to switch boards, bus ways, luminaries, wiring ducts, brackets, fixings, equipment, switches, outlet, wiring diagrams, wiring routes and equipment layouts.
- be marked or notated by the Engineer that construction or installation may commence, or alternatively marked or notated "Resubmit" which will automatically require the sample and/or drawing to be amended as required and resubmitted.
- be complete in detail to enable the Engineer to determine whether they comply with the requirements of the documents and whether they are suitable for their intended use and location.
- be submitted within sufficient time to permit modifications to be made without delaying the works if such are deemed necessary by the Engineer and to provide the Engineer with not less than seven (07) working days to make his comments.
- be submitted for ALL equipment, accessories, and systems for inspection prior to installation.

Drawings shall

- be supplied with a sufficient number of copies as required for co-ordination purposes.
- be drawn in ink to the following scales - 1:1, 1:5, 1:10, 1:20 for components and 1:50, 1:100 for locations, except for wiring diagrams which need not be to scale.
- be dimensioned in metric measurements.
- be amended as necessary and incorporated within the as-installed drawing set.
- be prepared to comply with British Standard for Engineering Drawing Practice, BS 308.
- Include dimensioned and detailed drawings for builder's work indicating locations and dimensions of penetrations, block outs and other works required.

Samples shall

- be held on site after inspection and used as a standard for acceptance or rejection of subsequent production units. Samples will be returned on completion of the project.
- be labelled to identify their intended use and relation to these documents.
- Subject to approval of the Engineer, where an item of equipment is a standard item copies of the manufacturer's catalogue or brochure may be accepted provided that all dimensions and relevant information are shown in the catalogue or brochure.

4.1.4 As- built Drawings, O&M Manuals

4.1.4.1 General

On completion of the works and 1 month prior to the issue of the Certificate of Practical Completion, provide as-installed drawings and manuals. Submit preliminary copies of the documents for inspection by the Engineer, who will indicate whether they are suitable or where they require modification. After approval, provide the original tracings or reproducible plus three (3) prints of the drawings and three (3) copies of the manual.

4.1.4.2 Drawings

The drawings shall be in the form of ink shall be prepared on AutoCAD.

Working drawings prepared and submitted prior to installation shall be amended to show all variations and may be accepted as the as-installed drawings for the portion of the works.

The drawings shall also show the following:

- The as-installed location of all outlets.
- Circuit grouping
- Switch grouping and position of switches
- The route of conduit runs concealed from view.
- The route of sub-mains.

- The route of underground wiring.
- The route of spare conduits suitably identified for the purpose.
- The location of switchboard.
- The route of cabling for emergency systems and the like.
- The arrangement of switchboards
- The arrangement and connection of sub main reticulation, including the size and type of cables (single line diagram).
- All relevant information which would assist the Proprietor in carrying out the Maintenance, additions and/or alterations to the installation.
- Quantities of the light fittings, socket outlets, switches etc shall be included in the drawing legend.

4.1.4.3 O & M Manuals

Equipment manuals (three off) shall comprise a plastic ring binder(s) with the project title, location, Proprietor's name, Contractor's name, Architect's name and Consulting Engineer's name embossed on the cover. The manuals shall incorporate the following information suitably grouped into appropriate sections in the manual.

A draft copy of the manual shall be submitted to the Engineer for approval, before submission of the final copies where manufacturers' drawings are included in the manual, they shall be folded and included within the manual, or alternatively bound separately and cross-referenced in the manual.

The content of a O&M manual will be listed as follows,

1. System overview
2. Operation procedure
 - 2.1. Modes of Operation
 - 2.2. Operating Instructions
3. Routing Maintenance & Trouble Shooting
 - 3.1. Routine Maintenance Schedule
 - 3.2. Manufacturer Recommended Service Procedure
 - 3.3. Trouble Shooting Procedure
4. Testing and Commissioning Reports
5. Technical Catalogues
6. Essential Spare Part List
7. Warrantee Certificate
8. Contact Details
9. Annexures

4.1.5 Testing & Commissioning

4.1.5.1 General

Before any of the systems are put into service, they shall be subjected to a commissioning and testing procedure. Provide all test instruments, other testing facilities required to verify system and equipment performance or complete all checklist records.

At least 2 weeks' notice prior to the start of the commissioning of any particular system will be given to project consultant, and shall submit his programme of testing and commissioning procedures for that system. He shall incorporate any modifications to that programme required by the Engineer.

4.1.5.2 Check List

Prepare a detailed and comprehensive checklist for the Engineer prior to commissioning and testing.

At least four months prior to the start of commissioning commence gathering information required for the checklist. Three months prior to the start of commissioning shall submit to the Project Manager the proposed checklist for approval.

The purpose of the checklist is to:

- Ensure that all items that should be checked are checked.
- Produce a permanent record of the commissioning checks carried out.

Accordingly, the checklist must be built up from information contained in this specification, from suppliers, manufacturers' installation and commissioning data and from experience in commissioning similar equipment and systems. The detail of the check list must be such that it can be completed with a reading or a tick which means that every device must be listed.

4.1.5.3 Procedure - General

Commissioning and testing procedures shall generally include

- Visual check of all work for completeness, and against diagrams of all wiring.
- Check that all work complies with the latest Regulations
- Check that all equipment is safe to operate, and that overloads, safety devices and inter locks are all in working order.
- Check operating sequences, function of all devices and rotation of motors.
- Verification of performance under site conditions, under load and simulated "worst case" condition.
- Insulation tests shall be made with 500V "Megger". No cable will be accepted with an insulation resistance, including termination, of less than 50 Mfl.
- Test continuity and unique identification of all conductors in all cables.
- Measure resistance of main earth and test all earth continuity connections.
- Check polarity and phase rotation of supply at all outlets.

4.1.5.4 Procedure - Equipment, Systems, Controls & Safety Devices.

- Check all work for completeness and proper working order.
- Test run all equipment for at least 24 hours.
- Check calibration and operation of each device.
- Check all batteries for full load output duration.

4.1.5.5 Procedure - Electrical

The checklist described above under 1.11.2 shall be based on ELECTRICAL SCHEDULE. Carry out all electrical and mechanical tests at the sit in the presence of a competent electrical Engineer.

Final tests shall be conducted in the presence of the Consultants. Provide all necessary instruments, test weights, connections, skilled and unskilled labour require for the test. The cost of such provision shall be included in the price.

After the commissioning tests have been concludes successfully, arrange for the inspection of the work s by the local authority for the issuing of Certificates for the electrical installation.

- Official report of installation
- Drawing card of installation
- Guarantee of installation

4.1.5.6 Authorities Inspection

Contractor shall carry out demonstrations of all systems as required by the authorities. Also allow for all pre - inspection testing until the Engineer is satisfied that all systems are ready for the authority's inspection.

4.1.5.7 Power Factor Balancing & Voltage Drop.

Provide automatic power factor correction equipment to maintain the power factor at the main switchboard between 0.90 and 0.98 Lagging.

4.1.5.8 Maintenance and Service.

Routine maintenance and servicing shall be carried out for a period of 12 months from date of Practical Completion to the end of the Defects Liability Period. Routine maintenance shall be carried out on monthly basis and emergency service on a 24 -hour call basis.

Maintenance procedures shall be in accordance with the manufacturers" requirements and as appropriate to ensure the safe and proper operation of the entire power generation system.

The contractor shall provide a Services Record Book, to approval, which shall include maintenance procedures and detailed check list for the full 12 month period.

At the conclusion of each site visit the Service Book with all check lists duly completed shall be submitted to the Building Engineer for signature and safe keeping.

A comprehensive typed report shall also be submitted to the building engineer within 3 days of an emergency service detailing the nature of the fault and the rectification works undertaken.

4.1.5.9 Regulations and standards.

Unless other specified, the Electrical Installation shall comply with the latest editions from time to time of the following documents:

- Relevant British Standard and Codes of Practice published by the British Standard Institution.
- The latest edition of IEE wiring regulation- BS7671- 2018.
- The requirement of Maldives Electricity Bureau.

Type test or certification of electrical equipment as specified in the specification herein shall be carried out by the institutions listed here below unless otherwise approved by the Consultant:

- ASTA - The Association of Short-Circuiting Testing Authorities
- BASEC - British Approvals for Electric Cables
- NEMA - National Electrical Manufacturer's Association
- UL - Under writer's Laboratories, Inc.

. It is to be noted that this installation has been designed to internationally accepted standards and codes of practice for electrical installations such as BS 7671 Requirements for Electrical Installations.

Recommended brand for specific items shall be considered for pricing.

4.1.5.10 Megger tests

All the main circuits and Sub circuits and final circuits shall be inspected, megger tested and approved by a Chartered Electrical Engineer registered with Maldives Electricity Bureau. The contractor shall bear the cost for, the above certification. The contractor shall make records of all tests shall be conducted in the presence of and to the satisfaction of the Engineer. Written reports of the results of all tests etc. shall be submitted in duplicate by the Contractor to the Engineer and Employer's representative.

The Contractor shall be responsible for the testing of all switchboards, sub-main cabling final subcircuits, protective conductor continuity grounding, etc., according to Maldives Regulations for supplying electricity to Male'and other islands, IEE : Wiring Regulation and local authorities" requirements.

Generally, tests shall include the following:

- Continuity of protective conductors
- Continuity of ring final circuit conductors
- Insulation resistance
- Protection against direct contact, by barriers or enclosures provided during erection
- e) Polarity f) Earth fault loop impedance
- g) Earth electrode resistance.

- h) Correct operation of interlocks, tripping closing circuits and indications
- Any other tests as reasonably required by the Employer's representative.

1.2 Electrical Distribution System

1.2.1 Electricity Supply

The electricity supply will be sourced from State Electric Company Limited (STELCO). LV feeder connection which will be drawn from the existing cable infrastructure, is available near the development. In accordance with STELCO regulations, the feeders will be drawn into the development and terminated into a STELCO metering panel at the ground level.

The low voltage supply from the STELCO meter panel will be distributed to the Main Switchboard (MSB).

1.2.2 Color code for cables

Maintain the same color code to all sub-mains, switchboards and multi-phase outlets throughout the installation.

The following terminology shall be followed as per the latest BS7671 - 18th Edition:

A phase	- Brown
B phase	- Black
C phase	- Grey
Neutral	- Blue
Earth	- Green and Yellow

1.3 Low Voltage Installation

1.3.1 Earthing

Earthing system is partially completed at site and contractor shall responsible for overall earthing system with completing of balance work.

The electrical system earthing shall:

- Comply with IEE Wiring Regulations - BS 7671 18th Edition.
- Be in accordance with Maldives Electricity Bureau requirements.
- Comprise a network of bonding between equipment, electrodes and service

mains. The main earthing conductor shall:

- Be run to and connected to a bolted, labelled connection on the earth electrodes.
- Be bonded to the incoming water supply for domestic and fire services
- Be provided with an engraved label with re filled letters inscribed - "MAIN EARTH - DO NOT DETACH".
- Be green/yellow PVC covered, 120mm² Cu/PVC (E) a separate earthing system to telephone distribution frames, electrodes etc.

Earth electrodes shall be:

- Be installed beyond the building's footprint to avoid possible interaction with the building's

lightning system earth.

- 19 mm diameter extensible copper 2 m in length per section driven to a maximum depth of 8 m
- A minimum of two, but sufficient in number to achieve the necessary resistance to earth of not more than three (3) ohms.
- Installed not less than 0.5m from any buried metallic services to reduce possible Electrolytic action
- Installed within a “Fibrolite” pit fitted with a lid inscribed in red filled letters - MAIN EARTH - DO NOT DISCONNECT”
- driven into the ground by mechanical hammering.
- Provide earthing to:
 - All exposed metal parts forming part of this installation
 - All metal conduits, cable trays, trunking and ducts
 - Cable sheaths and armouring
 - Metal mullions of office partitions, which contain switches or outlets
 - Luminaries, equipment enclosures and switchboards.
 - To the computer/PABX equipment comprising a separate 25 mm² clean earth cable direct from the main earthing bar in the main switch room

Provide earth bonding to:

- All metal pipes entering or leaving the building.
- Major internal piping systems, such as chilled water, reticulated gas systems, steam piping, and the like.

Earth connections for lift sub mains shall be a brass bolt, stud or screw, not less than 6mm nominal diameter.

Circuit protective conductors:

- Circuit protective conductors may be formed by a separate conductor/cable, the metallic sheath or Armour of a cable, part of the same cable as the associated live conductor, trunking or ducting, or the metal enclosure of the wiring system. Flexible conduits, PVC conduits, the exposed conductive parts of equipment shall not form, part of the circuit protective conductors.
- For every socket outlet, a separate circuit protective conductor shall be provided connecting the earth terminal of the socket outlet and that inside the enclosure accommodating the socket outlet.
- For every length of flexible metal conduits, a separate circuit protective conductor shall be provided inside the conduit to ensure the earth continuity of the installation between the two ends of the conduit.
- Provision shall be made in an accessible position for disconnecting a protective conductor from the main earthing terminal or the earth electrode to permit testing and measurements of earthing resistance, No switching device shall be inserted in a protective conductor.
- All cables used as protective conductors, including earthing conductors, main equipotential bonding conductors, supplementary bonding conductors and circuit

- protective conductors shall be identified by the colour combination “green and yellow”.
- All circuit protective conductors shall be PVC insulated.
- The cross sectional area of a protective conductors, excluding equipotential bonding conductors, shall be determined by the adiabatic equation given in Regulation 543-2 or in accordance with Table 54F of the IEE wiring Regulations 18th Edition. Where a protective conductor does not form part of a cable and is not formed by, or not contained in, steel conduit, trunking, ducting or other metallic enclosure of a wiring system, the cross sectional area shall not be less than 4 mm². When a separate cable is used as a CPC, the cable shall be insulated to BS 6004 - 1984, Table (1a) or better unless its CSA is greater than 6 sq.mm. When metal enclosures for cables are used as protective conductors, they shall have CSA equivalent to that of copper, not less than that resulting from the above-mentioned adiabatic equation.
- Where protective conductors are buried in the soil, they shall have minimum CSA as given in table 54A of the IEE Wiring Regulations, 18th Edition.

1.3.2 Mains & Sub Mains

All mains and sub-mains shall:

- Be provided to all switchboards and control panels on the site.
- Be of the size and type as shown on the single line diagrams.
- Follow the basic routes as indicated on the drawings, however, it shall be the contractors' responsibility to fully co-ordinate all sub main routes with the structure and other services.
- Unless otherwise stated, be installed in a manner to achieve the current ratings stated in “IEE Wiring Requirements for Electrical Installations” for PVC/PVC and/or XLPE/PVC cables as applicable.
- Be identified at tap-off boxes and switch boards by approved labels fixed to the cover plates identifying the cable size, type and purpose.

Where sub mains are provided to equipment supplied by others, provide the details of all bus bars, fixings, studs and clearances which will be required to be incorporated within the equipment for the satisfactory termination of the cables.

Terminate and connect cables to equipment supplied by others unless otherwise specified herein. The IP ratings of the Main DB shall be IP54 and Sub DB's & consumer units IP54 unless otherwise specified.

1.3.3 Low Voltage Switchgear Assemblies

1.3.3.1 Scope of Work.

This Specification relates to Type Tested Assemblies (TTA) and Non Type Tested Assemblies all switchgears must be type tested. Type test certificates together with the construction details of the board on which the approval was obtained shall be submitted at the time of material submission.

All assemblies shall be capable of withstanding the electrical, mechanical and thermal stresses of making and breaking the prospective fault level and normal loads without any damage. The prospective fault levels of the various assemblies are as indicated in drawings.

Shop/Fabrication Drawings shall include fully dimensioned external and internal general arrangement drawings showing all principal dimensions, weights, foundation/cable entry details and the positions of all functional devices, busbars and cabling chambers.

Schematic drawings showing all busbars, risers, functional units and other components together with the sizes/ratings of all conductors and functional units, wire numbers and terminal markings, short-circuit withstand strength and IP rating shall be supplied before manufacture of the assemblies commence.

The assemblies shall be of the totally enclosed, modular, cubicle type, which are extensible and suitable for floor or wall mounting as shown in the drawings.

1.3.3.2 Definitions

Unless otherwise specified all terms shall be as defined in BS 4727 and BS EN 60439, and related documents.

The assembly type and functional content shall be as specified in this Specification and the associated drawings.

1.3.3.3 Standards and Regulations

The design, manufacture, selection, installation, testing, commissioning, including consideration for future maintenance by others, of all equipment and materials described in this Specification shall comply with the requirements of BS EN 60439. Maldives Electricity Bureau, The Electricity at Work Regulations, the IEE Wiring Regulations and the documents referenced in each of these publications. Equipment and systems shall conform to the requirements of DISC PD2000-1 Published by BSI.

Where more onerous requirements are specified herein, the conditions of this Specification shall take precedence.

1.3.3.4 Service Condition

The assemblies described in this Specification and drawings shall be suitable for use under the ambient air conditions not exceeding 40°C and average of 35°C over a 24 hours period, with relative humidity of 95%. The altitude does not exceed 2000m and to comply with salty environmental conditions.

1.3.3.5 Degree of Protection (IP rating) and Form of Construction

The minimum acceptable form of construction and degree of ingress protection (IP rating to BS EN 60947- 1) from all directions of the installed assembly shall be as follows, unless otherwise shown on the drawings or bill of quantity.

Main Switch Board	IP54	Form 3b
Sub Main Switch Boards	IP54	Form 1
Distribution boards	IP54	Form 1

1.3.3.6 Transportation

The assembly shall be suitably protected for transportation and storage in a temperature range between -25 deg C and +55 deg C, and for short periods not exceeding 24h, up to +70 deg C.

Equipment subjected to these extreme temperatures without being operated shall not undergo any irreversible damage and shall operate normally in the specified conditions.

The assembly shall include provision to cater for moderate condensation, which may occasionally occur due to variations in temperature within the ranges specified for normal operation, transportation and storage. Panels shall be divided into sections of about 2 meters width to enable easy handling and transportation.

1.3.3.7 Drawings

The Contractor shall submit workshop drawings of all switchboards for approval before manufacture. Drawings shall be in the format specified herein and show the following information.

- Manufacturer's name and catalogue number of any standard equipment.
- The general arrangement of equipment.
- Full details of cabinet construction and dimensions.
- The method of supporting bus bars and equipment.
- A description of all materials to be used.
- Clearance between live parts, and live parts and earth.
- Bus bar dimensions and ratings.
- Internal wiring sizes and ratings
- The size and wording of labels.
- Wiring diagrams and schematics of instrument protection and control circuits
- Front elevation of switchboard
- Vertical section through each compartment.
- Sheet metal details
- Weights of switchboards heavier than 500kg.

1.3.3.8 Approved Switchboard Manufacturer.

Main switch boards shall only be manufactured by firms who are able to provide Type Tested Designs in accordance with BS 5486 Part I, BS 7671 and statutory authorities and the fault rating clause 04 of this section of the specification.

The contractor must nominate the proposed manufacturer in the tender submission for approval by the Consulting Engineer.

Tenders based on non-conforming switch board manufacturers may be rejected at the discretion of the Consultants.

1.3.3.9 Construction of Panel boards

1.3.3.9.1 Main Switch Boards

1.3.3.9.1.1 Type

The MSB shall be a rear connected, free standing, sheet metal cubicle type board with bottom and top cable entry. The MSB enclosure shall be powder coated ZnAl enclosure preferably manufactured by a Panel manufacturer with more than 5 years experience in the trade. Refer section 1.3.3.5 for degree of protection and Form of segregation of panel boards.

1.3.3.9.1.2 Fault Rating

The fault rating at the MSB shall be 36kA of 400V for 1 sec.

The bus bar system shall be manufactured in accordance with a “Type Tested Design” which has demonstrated that it is capable of withstanding the thermal and magnetic effects of a fault of this magnitude for a period of 1 second. All components used in the Switch board shall be rated for this fault level. Fault Current Limiting will not be allowed in the Main Switch Board.

1.3.3.9.1.3 Type and Materials

All assemblies shall be of the enclosed type comprising the cubicle or multiple cubicles.

Cubicle sizes shall be suitable for easy access and maintenance of the functional units and associated equipment mounted in the individual cubicles. Space shall be provided to allow an overall increase of the specified functional units as specified.

Equipment for indication and/or operation shall be mounted not less than 300mm and not more than 1800mm above finished floor level.

The MSB cubicle shall be:

- Be Constructed from mild steel angle iron frame work with separate cover plates of 2mm (minimum) bright mild steel or,
- Be of unitary folded and welded construction, fabricated from minimum 2 mm thick bright mild steel or,
- Be assembled from the prefabricated components of a Proprietary Modular Switchboard System. Separate cubicles shall be bolted together in an approved manner providing a rigid structure.

1.3.3.9.1.4 Doors and Covers

Full access shall be provided to service and maintain all equipment inside each cubicle by means of a suitable lift off hinged door, which shall open a minimum of 150 degrees.

Panels longer than 1.2 metres shall be provided with 3-point locking system while smaller panels shall be provided with 2-point locking system.

All doors and covers shall have folded edges and additional bracing to eliminate whip. All doors

and covers shall be sealed as appropriate to meet the specified IP rating.

All non-interlocked doors shall be fitted with suitable cylinder locks. Each cylinder lock shall be supplied with two keys. All removable covers shall be fitted with suitable zinc plated self-aligning fixing screws.

Panel construction shall be such that component manufacturer's clearances are observed, and adequate

ventilation shall be provided for heat dissipation.

All air Inlets shall be fitted with a vermin mesh and air filtration shall be provided.

Ventilation arrangements to meet the scheduled requirement shall be detailed on the Manufacturer's and/or Fabrication Drawings.

No "Live" parts of components shall be mounted on the door. Operating devices such as Indicating lamps, push buttons, selector switches, meters, etc. shall be so mounted that all live carrying parts are mounted within the panels when the doors are open. Only the operating handle and none "Live" parts shall be allowed to be mounted on the door. If live parts are to be mounted on the door they must be double insulated and the back terminals protected with a transparent polycarbonate cover. All doors shall be independently earthed to the switchboard frame using a braided or coiled copper cable. All non-current carrying metal work on the switchboard shall be bonded to the main earth bar.

1.3.3.9.1.5 Penetrations

Where it is necessary for cables and/or conduits to enter assemblies and/or pass between compartments, flexible grommets or glands shall be used. Provision shall be made for proper support and bracing for all incoming and outgoing cables.

Single core cable penetrations shall utilize brass or polyamide gland plates of 6mm thickness. The glands and plates shall be effectively earthed.

Earthing of the armour of single core cable shall only be affected on the source side of the cable, while the other end is left unconnected. For single core cables whose length exceeds 100m, the armour shall be cross-linked and bonded to earth at every 50m interval.

1.3.3.9.1.6 Functional Units

Each functional unit shall have an integral isolating switch, the operating handle of which shall be interlocked with the door, which in the open position shall isolate all incoming supplies including low voltage control circuits.

1.3.3.9.1.7 Steel Enclosures

Steel enclosures of assemblies shall be constructed to BS EN 10130 Series. Contractor shall provide Free standing and wall mounted enclosures as follows.

Free Standing		Wall Mounted	
Base frame	2.0mm	Mounting Plate	2.0mm
Doors/Covers	1.5mm	Doors/Covers	1.0mm ~1.5mm
Cover plate	1.2mm~1.5mm	Cover Plate	1.2mm

Table 2.1 Thickness of steel enclosures

Alternative thickness of sheet steel will be considered if additional bracings are provided to suit the sheet steel thickness offered. Synthetic transparent material may be used on viewing panels and on the doors for kWh meters.

All necessary holes and slots shall be formed prior to cleaning and finishing.

All component parts shall be cleaned to comply with the paint manufacturers' recommendations, following which they shall be finished with an epoxy or polyester powder paint which is oven cured. Paint colour shall be manufacturers standard, unless otherwise specified.

1.3.3.9.1.8 Lifting

The MSB shall be provided with removable lifting eyebolts.

1.3.3.9.1.9 Ventilation

The MSB shall contain louvered vents at the top and bottom with fine bronze wire mesh welded inside.

1.3.3.9.1.10 Finishes & Hardware

The MSB shall be painted and provided with hardware in accordance with this specification.

1.3.3.9.1.11 Cable Provisions The MSB shall be:

Provided with non-ferrous gland plates for all incoming and outgoing cables. Gland plates shall be sized to suit the cables specified and positioned to suit the site conditions. Provided with sufficient and suitable space for the installation of incoming and outgoing cables so that:

- Cables are not bent beyond their minimum allowable bending radii
- Cable terminations are not subject to physical stress
- Cables do not suffer derating
- Cables are kept clear of bus bars and functional

units. Provided with appropriate means of securing cables, including:

- Cable cleats and/or cable tray for mains and sub mains
- Slotted PVC Duct for control cabling

Provided with bushed holes where cables pass between compartments.

1.3.3.9.2 Distribution Boards (DBs including FDBs, SDBs, DBs)

1.3.3.9.2.1 Type

DB"s shall be wall mounted and/or floor standing, front connected, sheet metal powder coated panel boards

with top and/or bottom cable entry. Full access shall be provided to the switches and control equipment inside the cubicles by means of suitable door, secured in closed position by means of key operated catches. The doors shall be fitted with strengthening strips to give the necessary rigidity. Also this will be a dead-front construction equipped with thermal magnetic or electronic trip unit main and branch circuit breakers of frame sizes, and trip ratings indicated in the drawings or distribution board (DB) schedules.

Refer section 1.3.3.5 for degree of protection and Form of segregation of panel boards.

"Danger" signs and electric shock treatment charts shall be supplied and installed in every switch room and load center. The switchboards shall incorporate suitable protective measure such as partitioning between sections, subsections, shutters and interlock etc, for protection against internal arcing, contact with live parts etc.

1.3.3.9.2.2 Fault Rating

The fault rating of DB's is indicated on the drawings; Fault Current limiters may be provided to enable the use of miniature circuit breakers with a lesser fault rating. The minimum current density shall be 155A per square centimeter. However, the ratings shall also be established by heat riser tests with in a maximum hot spot temperature on any connector or bus bar not exceeding 55°C rise above ambient temperature.

DB's shall incorporate proprietary type tested bus bar assemblies with a minimum fault rating of 10 kA for 1 sec or greater or as indicated on the electrical drawings.

1.3.3.9.2.3 Doors and Covers

Full access shall be provided to service and maintain all equipment inside each cubicle by means of a suitable lift off hinged door, which shall open a minimum of 150 degrees.

Panels longer than 1.2 metres shall be provided with 3-point locking system while smaller panels shall be provided with 2-point locking system.

All doors and covers shall have folded edges and additional bracing to eliminate whip. All doors and covers shall be sealed as appropriate to meet the specified IP rating.

All non-interlocked doors shall be fitted with suitable cylinder locks. Each cylinder lock shall be supplied with two keys. All removable covers shall be fitted with suitable zinc plated self-aligning fixing screws.

Panel construction shall be such that component manufacturer's clearances are observed, and adequate ventilation shall be provided for heat dissipation.

All air Inlets shall be fitted with a vermin mesh and air filtration shall be provided.

Ventilation arrangements to meet the scheduled requirement shall be detailed on the Manufacturer's and/or Fabrication Drawings.

No "Live" parts of components shall be mounted on the door. Operating devices such as Indicating lamps, push buttons, selector switches, meters, etc. shall be so mounted that all live carrying parts are mounted within the panels when the doors are open. Only the operating handle and none "Live" parts shall be allowed to be mounted on the door. If live parts are to be mounted on the door they must be double insulated and the back terminals protected with a transparent polycarbonate cover. All doors shall be independently earthed

to the switchboard frame using a braided or coiled copper cable. All non-current carrying metal work on the switchboard shall be bonded to the main earth bar.

1.3.3.9.2.4 Steel Enclosures

Steel enclosures of assemblies shall be constructed to BS EN 10130 Series. Contractor shall provide Free standing and wall mounted enclosures as follows.

Free Standing		Wall Mounted	
Base frame	2.0mm	Mounting Plate	2.0mm
Doors/Covers	1.5mm	Doors/Covers	1.0mm ~1.5mm
Cover plate	1.2mm~1.5mm	Cover Plate	1.2mm

Table 2.2 Thickness of steel enclosures

Alternative thickness of sheet steel will be considered if additional bracings are provided to suit the sheet steel thickness offered. Synthetic transparent material may be used on viewing panels and on the doors for kWh meters.

All necessary holes and slots shall be formed prior to cleaning and finishing.

All component parts shall be cleaned to comply with the paint manufacturers' recommendations, following which they shall be finished with an epoxy or polyester powder paint which is oven cured. Paint colour shall be manufacturers standard, unless otherwise specified.

1.3.3.9.2.5 Cable Provisions

The DBs shall be:

- Provided with non-ferrous gland plates for all incoming and outgoing cables. Gland plates shall be sized to suit the cables specified and positioned to suit the site conditions.
- Provided with sufficient and suitable space for the installation of incoming and outgoing cables so that:
 - o Cables are not bend beyond their minimum allowable bending radius
 - o Cable terminations are not subject to physical stress
 - o Cables do not suffer derating
 - o Cables are kept clear of bus bars and functional units.
- Provided with appropriate means of securing cables,
 - including: O Cable cleats and/or cable tray for mains
 - and sub mains O Slotted PVC Duct for control
 - cabling

Provided with bushed holes where cables pass between compartments.

1.3.3.10 Escutcheons (Dead Front Configuration)

All switchboards shall be provided with escutcheon panels incorporating cut outs, which allow only toggles, handles, indicators, dials and like equipment for operational use to protrude through.

Escutcheon Panels shall:

- Be fabricated from 1.6 mm (minimum) folded bright mild steel.
- Be not larger than one meter in height or width, and in no case exceed 0.8m² in area.
- Incorporate cutouts, which expose only toggles, handles, indicators, dials and the like
- Incorporate cut outs for single pole breakers when multi-pole circuit breakers can be replaced with single pole breakers.
- Be provided with folded metal stiffeners and bracing to achieve rigidity and prevent warping or sagging where long cut outs are provided for equipment groups.
- Have edges folded to provide a 12mm deep return
- Be provided with two (2) lifting handles.
- Be secured by means of four (4) (minimum) large diameter, chrome plated, captive, knurled, cylindrical head nuts with nylon washers on to replaceable threaded studs fixed to the switchboard body, or by means of four (4) (minimum) large head chromium plated screws with nylon washers in conjunction with two (2) locating dowels fixed to the switch board body which pass through close tolerance holes in the escutcheon to support the weight of the escutcheon whilst the screws are being removed or installed.
- Alternatively, escutcheons may be provided with lift off pintle style hinges and secured using either of the above methods
- Contain plastic inserts or painted metal covers over unused openings.

1.3.3.11 Electrical Construction

1.3.3.11.1 General Requirements

The physical condition, electrical and mechanical properties of connections and terminations of all current carrying parts shall not deteriorate as a result of normal operation.

Fixed connections between current carrying parts shall comply with recommendations of Copper Development Association.

1.3.3.11.2 Busbars

Busbars within the switchboard shall:

- Comply with BS 5486 Part 1
- be of tinned hard drawn copper ampere rates shall be as mentioned in the drawings
- be installed according to the following method. Neutral and earth bars shall be of solderless screwed-on mechanical type connectors. The neutral bars shall be mounted to the DB by non- hygroscopic insulators. The insulation of resistance for neutral bars to the metal enclosure shall be infinity and for earth bars to metal enclosure shall be zero. The number of neutral terminals to be provided shall be the same as the total number of branch circuit breakers ways plus one for incoming feeder neutral cable. Whereas, number of earth terminals to be provided shall be the same as the total number of branch circuit breakers ways plus one for incoming earth cable and the

number of bonding cables.

- be manufactured from high conductivity hard drawn copper bar with radius edges to BS 1432 and BS 1433 with electro tinned finish.
- be of sufficient cross-sectional area to supply the capacity of the switch board when all space on the switch board is filled. The bus bars shall have a maximum current density of 155 Amperes per sq. cm. or cross-sectional area.
- be sized to limit temperature rise to 45°C for the main switch board and to 75°C for distribution boards above an ambient of 40°C when carrying rated currents in enclosures of magnetic material
- be of minimum size 12mm x 3mm except for tee offs to miniature circuit breakers.
- be suitably tinned for aluminum cable lug terminations
- be arranged for miniature over current circuit breakers so that a multi-pole circuit breaker can be replaced with single pole breakers without disturbing the 3 phase bus bar assembly.
- have the phase busbars fully protected with an integral, high impact, thermoplastic shroud. Bussing assembly shall standard factory make product by renowned manufacturer. Withstand capability of kVA r.m.s symmetrical for 1 sec at 415 Volts incoming Icu(kA) for 1 sec at 400V .

Incoming Capacity (kVA)	Icu (kA) for 3 sec
1000	28
1250	30
1600	38
2000	48
2500	60
3000	75

Table 2.3 Short Circuit Withstand Capacity

The above-mentioned ratings shall be established by heat rise tests with maximum hot spot temperature rise on any connector or busbar not exceeding 50 °C above ambient (based on an ambient temperature having value not exceeding 40 °C and an average value not exceeding 35°C measure over a 24 hour period.

- have neutral bus bars of the same current rating and size as the phases.
- be used for all connections carrying 100A or above.
- be arranged so that all joints, terminations and fixing are fully accessible.
- be disposed and supported so that under short circuit conditions no bus bar material is stressed to more than 25% of its breaking load or 33% of its elastic limit (whichever is the lesser).
- be arranged so that they can safely withstand the stresses caused by the prospective maximum fault current. The bus bar system up to the line side terminate of the main protective devices shall be capable of withstanding the thermal magnetic and physical stress set up by a fault of the magnitude

as shown on the drawing at 400 volts for 1 second. A copy of the “type test” certificate shall be submitted for the bus bar systems before manufacture of the switch boards will be permitted to commence.

All fabrication carried out there after must be in strict accordance with all dimensions and requirements of the “type test” have fully lapped silver plated joints finished, coated with acid free petroleum jelly and bolted together with cadmium plated steel bolts, large diameter washers and nuts. be provided with a removable section for the mounting of current transformers so that they may be removed or replaced without disturbing the reminder of the switch board. be supported on synthetic resin moulded type insulators, panels and cleats. The use of bobbin type insulators secured through the bus bar is not acceptable. pass through 12 mm (minimum) thick close fitting insulated panels through a single hole in metal work where installed from one compartment to another. be phase coloured as follows:

- | | | |
|-----------|---|-----------|
| ■ A phase | - | Brown |
| ■ B phase | - | Black |
| ■ C phase | - | Grey |
| ■ Neutral | - | Blue |
| ■ Earth | - | Green and |

Yellow be fully insulated by:

- PVC dipping with a minimum of two (2) coats, or
- PVC encapsulation, or
- Shrink-on PVC sleeving with taped joints

1.3.3.11.3 Links

Links for terminating neutral and earthing connections shall be:

- of brass or copper and square or rectangular section
- provided with the same number of terminals as there are active poles and numbered to correspond.
- be fitted with tunnel type terminals for cables up to 6 sq.mm and stud type terminals to accept cable lugs for other cables.
- installed over the full length of multi compartmented switch boards.
- fully accessible.

1.3.3.11.4 Main Circuits

Main circuit wiring shall be PVC insulated to BS 6231, Type BR, and, where appropriate, sized for Type 2 protection coordination to IEC 947, but with a minimum cpc size of 2.5mm².

Connections to and from functional units shall be segregated from control wiring and adequately supported to withstand the forces due to short-circuit faults. The sizes of wires shall be calculated in accordance with the IEE Wiring Regulations.

All cable connections shall be made at fixed terminals with no intermediate joints. Insulated conductors shall not rest against bare live parts or exposed sharp edges.

1.3.3.11.5 Switching/Protective Devices

1.3.3.11.5.1 Switches and Isolators

All switches and isolators rated at 50A and above.

- shall comply with BS 5419
- shall be fault making and load breaking.
- be rated for uninterrupted duty
- shall be spring assisted manual closing
- shall be suitable for the prospective fault current specified herein.
- shall include a mechanical “on” AND “OFF” visual indicator linked directly to the main contact movement.

1.3.3.11.5.2 Circuit Breakers

Miniature circuit breakers (MCBs)

shall:

- be designed to withstand 25,000 switching at rated current and voltage with a power factor of 0.95
- be designed to withstand 50,000 switching at no load
- Incorporate the following:
 - arc interrupting device
 - inverse time current characteristic
 - trip to operate when breaker is locked on
- comply with IEC 947-2, BS 3871 and BS 4752 as applicable
- have an interrupting capacity adequate for the maximum prospective fault current to which they may be subjected, and not less than 6 kV
- incorporate similar features and uniformity of style regardless of frame size and

rating. Moulded case circuit breakers (MCCBs) shall:

- incorporate similar features as listed for miniature circuit breakers.
- comply with IEC 947, BS 4752 and BS 3871
- have ambient temperature compensation for breakers over 160 amps.
- have the short circuit breaking capacity higher than the Prospective Short Circuit Current of the point of installation. The breaker shall be of moulded material with good mechanical strength.
- have minimum interrupting capacities of R.M.S symmetrical amperes at 400 Volts A.C
- as the associated switchboard or as stated on the drawing.
- shall be calibrated at ambient temperature of 40 °C and carry their rated current continuously, when operated in free air at this temperature.
- have each pole, factory calibrated with thermal bi-metal over current element with inverse time delay characteristic and the instantaneous magnetic tripping device has to be factory calibrated for short circuit condition.

have the Ambient temperature compensation accomplished by a secondary bi -metal that shall allow the circuit breaker to carry related current between 25 °C to 40 °C with tripping characteristics that are the same

throughout this temperature range without causing nuisance tripping. Terminals shall be constructed to assure maximum electrical contact and reliability, with minimized possibility of localized heating

Main Circuit breaker

The main circuit breakers for the incoming supply and the bus -tie breakers shall be fool proofed by interlocking both electrically and mechanically. Neutral links of incoming breakers if any, shall be easily accessible and removable and accessible from the front.

Residual Current Circuit Breakers (RCCB)

RCCBs shall be current operated type complying with BS EIV 61008-IIIIEC 1008. Sensitivity shall be as indicated in the drawing. RCCB shall have maximum tripping time $t < 40\text{ms}$ for 30mA and $40\text{ms} < t < 250\text{ms}$ for 100mA and above. For single phase supply RCCB shall be rated for 240V and for 3 phase supply 400V. They shall have the following features:-

- Surge withstands capability
 - Vibration proof
 - Pulsating D.C. current protection
 - Withstand relative humidity up to 95% at an ambient temperature of 45 °C
 - Trip free
 - Test button.

1.3.3.11.5.5 Fuses and Links

All fuses shall be High Rupturing Capacity (HRC) type fault current limiting fuses in distribution boards may be DIN type. Other fuse carriers and links shall comply with the following:

H. R.C fuse carriers and bases shall:

- comply with IEC 269
- have a moulded plastic insulated fuse carrier;
- have a fuse indicator which is visible without the need to remove the fuse
- have fully shrouded base contacts.
- be of G.E.C. or approved equal. H.R.C. fuse cartridges shall:
 - be certified for a fusing factor of Class 01
 - be GEC/English Electric Type 1 or approved equivalent.

Three spare HRC fuse cartridges of each rating and type used (including fault current limiting fuses) shall be provided on a labelled panel adjacent Each switchboard.

I. 3.3.11.5.6 Automatic Transfer Switches

Automatic Transfer switches shall be complying to IEC 60439-1, IEC 60529, IEC 60947, IEC 60051 and type containing two moulded case/air circuit breakers and a geared electronic motor.

Low voltage automatic transfer changeover switches shall be of four (4) poles, flush mounted, front access type. They shall comply fully with B.S or I.E.C or U.L and shall have the same interrupting capacity I_{cu} at 400 volts a.c. 50 Hz as the interrupting capacity (kA) of the associated incoming circuit breaker switchboard

for 1 (one) second in accordance with the above specifications.

Mechanical and electrical interlocking in Low voltage automatic transfer change over switches shall be provided to prevent:

- Neutral position shall not be possible under automatic electrical operation.
- Normal and emergency sources shall not simultaneously connect, regardless of whether switch is electrically or manually operated.
- Switch shall have a manual neutral position
- Manual operation shall be accomplished by one person. The standard automatic transfer change over switch shall include but not limited to the following
 - (a) Complete protection, voltage sensing relays (one each phase)
 - (b) Time delay emergency to normal, solid state relay, adjustable from 0-120 sec.
 - (c) Engine starts contact and termination block(s).
 - (d) Breaker auxiliary contact, normal source.
 - (e) Breaker auxiliary contact, emergency source.
 - (f) Two 4P MOTORIZED Air circuit breakers.
 - (g) Mechanical and electrical interlocking
 - (h) Test push button.

The circuit breakers shall be rated as specified in the drawings, and neutral unstitched.

The common transfer mechanism shall be electrically operated with all parts in positive contact at all times. It shall also be capable of being operated manually and shall have suitable provisions for readily disengaging the gear motor when so operated.

The transfer switch shall be mechanically and electrically interlocked so that neutral position shall not be possible when under electrical operation. It shall not be possible for load circuits to be connected to normal and emergency sources simultaneously, regardless of whether the switch is electrically or manually operated, or if any part should malfunction.

Provide two adjustable time delay functions each of 10-20 seconds duration in the neutral position when the load is disconnected upon transfer from either

- Normal to emergency Supply, or
- Emergency to Normal Supply

All accessories and equipment shall be front accessible for ease of maintenance or removal.

Components of the operating mechanism shall be insulated or electrically dead.

Components of linkages and handles in operating mechanisms shall be ruggedly constructed and not subject to deterioration. Medium or light duty plastic components will not be accepted.

Pilot light indication of circuit breaker status shall be provided for each transfer switch as follows:

- Normal Supply Breaker closed: Green
- Emergency Supply Breaker closed: Green

A rotary type control selector for the transfer switch shall have the following positions

- Normal Supply
- Automatic
- Auxiliary Supply

In the automatic position the supervisory circuit shall monitor the normal supply and in the event of failure shall cause the load to be transferred to the Auxiliary Supply when it becomes available.

Adjustable time delays shall be incorporated in the supervisory circuit to prevent transfer during short periods of supply failure.

Phase failure relays shall monitor 3 phase supplies for correct phase rotation, voltage balance with a 15% adjustable setting and 80% under voltage setting.

1.3.3.11.5.7 Contactors

Contractors shall:

- Comply with IEC 947 - Part I
- be suitable for AC 3 utilization category
- have a minimum current rating not less than that specified or the protective device immediately preceding where no rating is specified.
- be suitable for uninterrupted duty
- have type 2 short circuit co-ordination with the protection device preceding it.
- be suitable for 50.000 switching operations
- be four (4) pole for change over contractors
- be of approved make.
- have 2 sets of normally open and normally closed auxiliary contact with 10 amps minimum rating.
- have renewable contacts and operating coils.

1.3.3.11.6 Instrumentation & Metering

1.3.3.11.6.1 General All meters shall:

- comply with IEC 258 for accuracies class 2.5.
- be compatible for remote metering facility with BMS integration.
- be industrial grade with shock resistant jewel bearings.
- be of the flush mounted type, square fronted of dimensions 96mm x 96mm with a quadrant scale.
- have suppressed zero, compressed overshoot and/or non linear scales as required by the range of measurement.
- be provided with a means of zero adjustment without the need for any dismantling.
- have a deflection of approximately 80% full scale range with a 5A load.
- be suitable for continuous duty
- have direct reading scales graduated to suit each application

- have dials with black characters on a white back ground

1.3.3.11.6.2 Power Quality Meters

Provide electronic multifunction meters on each transformer supply and each emergency generator supply. Power quality meters shall be included to measure third harmonics.

Each shall provide the following information/features

- Volts L - N for each phase
- Amperes for each phase
- Watts
- Volt Amps
- Var
- Power factor (True PF & Displacement)
- kWh
- kVA demand
- True RMS measurement
- RS 485 serial communications port
- 4 wire three phase unbalanced load
- Peak values for each parameter
- LCD multiline graphic display module with back

light Front mounted keypad for user programming and display switching

1.3.3.11.6.3 Current Transformers Current transformers shall:

- comply with BS 3938/IEC185
- be class 1M for metering class 2M for maximum demand metering and class 2.5P for protection.
- be of the resin-encapsulated type
- have 5A secondary windings
- be separate units for metering and protection
- be suitable to withstand the maximum fault current as specified herein.
- be clearly labelled to identify their rating and use
- be capable of operating the load of the related device with an additional capacity of 5%.

1.3.3.11.6.4 Controls

Auxiliary and control switches shall:

- comply with IEC 947
- have contacts of minimum 10A continuous rating.
- be rotary snap action type
- be of approved manufacture.

1.3.3.11.6.5 Indicator Lights Panel mounted

indicator lights shall:

- comply with IEC 947
- have domed lenses of 19mm diameter minimum
- have neon lamps or light emitting diodes selected to be clearly visible in the ambient conditions.
- The (3) spare lamps (or diodes) of each size and type used shall be provided on a labelled panel adjacent each switchboard complete with re lamping tool if required.

1.3.3.11.6.6 Control Relays Control relays shall:

- have 5A minimum contact rating.
- be continuously rated.
- have silver contacts.
- have one (1) spare set of normally open and normally closed contacts.
- have surge suppression on coils.

Time delay relays shall be solid state electronic type.

1.3.3.11.7 Mounting on Equipment All equipment:

- shall be mounted within the switch board cabinet with only toggles, indicators, handles and dials protruding.
- shall be mounted on fixing rails or insulating panels.
- shall not rely on bus bars for support
- Shall be mounted to enable easy access for adjustment, replacement or maintenance
- Which is intended for future installation shall have mountings, studs, bus bar connections and escutcheon openings provided with painted blanking covers.
- Shall be installed so that a unit can be installed or replaced without disturbing adjacent units

Circuit Breakers rated above 100A:

- Shall be arranged for back connection where installed within free standing cubicle type switchboards
- Shall be arranged for front connection where installed within wall mounted switch boards..
- Shall be mounted so that the operating toggles of adjacent circuit breakers are in straight

alignment. Miniature circuit breakers:

- Shall be secured by separate clip-in type fixings as provided by the circuit breaker manufacturer..
- Shall be mounted on a lift out chassis assembly.

Fuse switch units shall be flush mounted for vertical operation of the handle so that the front covers provided with the unit can be opened or removed without removing the cover plates from the switchboards.

Current transformers shall be mounted within a removable section of bus bar so that they can be removed or replaced without disturbing other sections of the switchboard.

H. R.C. Fuses for fault current limiters shall NOT project through the front cover plates.

I. 3.3.11.8 Auxiliary Wiring

All instrument, indicator and control wiring shall:

- comply with BS 89
- be of stranded copper conductors, minimum size 2.5 sq mm V90 grade 0.6/1 KV PVC
- insulated.
- be supported on the square grid from using approved ducting and channels for groups of cables and approved plastic clips for single circuits.
- be identified using an engraved or moulded thimble suitably and securely fixed to the wire adjacent each terminal connection of the wire.
- be connected to approval 30A (minimum) rating terminal blocks of moulded insulating material which are labeled and numbered for the termination of all wiring which is external to the switch board.
- be terminated using approved crimping lugs.
- comprise flexible conductors where connected to equipment mounted on doors or in positions subject to movement.

1.3.3.11.9 Labels

All enclosures containing functional units shall be clearly labelled with a circuit, unit reference and current rating.

All labels shall be of the engraved type made from suitable multi-layer laminate and shall be fixed with zinc plated cheese head instrument screws. No other type of label will be acceptable.

Every functional unit shall be labelled separately from all others. External labels shall have letters not less than 5mm in height and internal labels not less than 3mm. The letters shall be black in colour on a white background.

All covers/doors not fitted with interlocked switched disconnectors enclosing unshrouded live equipment shall be fitted with warning labels inscribed 'DANGER 415 V ISOLATE BEFORE OPENING'. Warning labels shall have black letters on a bright yellow background. Wherever possible, letters shall be not less than 30mm in height. On small covers and doors letters of 20mm or 10mm in height shall be used.

Cable boxes shall be clearly labelled both externally and internally with the circuit and functional device number.

All terminal blocks shall be labelled relative to the respective functional unit. Every control and metering device, selector switch, pushbutton and indicator light shall be clearly labelled to indicate its purpose.

Main identification labels shall be provided on the assembly together with a rating plate.

Fixed and withdraw able portions of equipment including fixed and plug-in devices shall be labelled with withdraw able portions cross-referenced to their fixed part.

Proposed engraving details shall be submitted for comment prior to engraving. 1.3.3.11.10 Earthing

Each assembly shall be provided with a continuous copper earth bar running the whole length sized in accordance with BS 7430 for the prospective short-circuit current.

Discrete terminals shall be provided for connection to all the protective conductors. Each individual section of the assembly shall be separately bonded to the main earth bar.

1.3.3.11.11 Finishes Ferrous metal shall:

- be cleaned free from rust, corrosion, grease and scale.
- have rough surfaces filled and rubbed smooth.
- be painted using a coat of rust inhibiting self etching primer, and under coat of zinc enclosed paint and a coat of gloss enamel.
- have internal surfaces finished in gloss white colour. (Main switchboard only)
- have external surfaces finished in Orange No. 557 to BC 381 C Approved powder coatings may be submitted for approval.

A painted colour sample approximately 300 mm x 300 mm shall be submitted for approval before painting. Non-ferrous parts shall be cadmium plated or tinned. External handles, bolt heads, catches, locks, nuts and screws shall be stainless steel or chromium plated

1.3.3.12 Component

1.3.3.12.1 General Requirements

All components shall be installed in accordance with the instructions of their manufacturers. This requirement does not negate the requirement for type and routine testing as specified elsewhere in this Specification.

Adjusting and resetting devices shall be easily accessible.

All actuators for emergency switching devices shall be mounted between 0.8m and 1.6m above the base of the assembly.

All components shall be installed and wired such that their function is not impaired by interaction such as heat, arcs, vibration, and fields of energy present in normal operation.

Barriers for manual switching devices shall be designed such that arcs caused by switching under normal operation or the interruption or making of a fault current shall not present a danger to the operator.

All removable and withdraw able components shall be installed and designed such that they can be safely disconnected or connected to supply circuits whilst the associated conductors are live.

All spare contacts on relays, contactors, and the like shall be wired to easily accessible terminal blocks, suitably positioned for future external wiring.

Assemblies shall be provided with a spare set of fuses mounted on polyethylene coated spring clips adjacent to the fuse chart on the doors of a separate cubicle. A total of 20% of each size of fuse shall be provided with a minimum 4 of each size. When commissioning is complete the panel shall be handed over with this

complete set of spare fuses. A fully detailed fuse chart shall be provided in the same cubicle as the fuses. Where moulded case circuit breakers are installed they shall be fitted with rotary action handles. The handles shall be lockable in the 'ON' and 'OFF' positions.

1.3.3.12.2 Selector Switches / Push-Buttons / Indicator Lamps

The manufacturer's range shall include fully interchangeable contact blocks and lamp holder blocks which can be fitted to all actuators including switches and push-buttons.

Selector switches shall be of the rotary type, with lever or key operated actuators as specified or shown on the drawings.

Push buttons shall be of the flush type. Colours shall be as specified in BS EN 60073. Red for stop/emergency stop (mushroom head with twist to release), green for start, and light blue for reset activity.

For All BMS operated Lighting circuits shall be able to be operated via manual push buttons and Auto/manual selector switch shall also be provided.

Pushbuttons used for emergency stop purposes shall be of the mushroom head type, with a twist to release action. Key reset type pushbuttons shall be supplied if shown in the drawings. Contact blocks shall have double break silver plated contacts, in 'NO' or 'NC' configuration rated at not less than 5A resistive at 250V 50Hz.

Indicating lamps shall be of the flush type 22mm diameter with removable coloured lenses, allowing lamps to be changed from the front and shall be provided with a push to test facility. Colours shall be as specified in the BS EN 60073. Red for trip/alarm or to indicate parameters outside safe limit, yellow for warning of parameters outside normal limits, green for normal operation, white for supply available, blue for specific meaning as labelled and a flashing light to draw attention. A flashing light of the corresponding colour may be used to draw attention to a fault or abnormal condition where appropriate. Flashing lights must be acknowledged by a pushbutton operation on the lamp or other button arrangement.

Indicating lamps on control circuits shall be equipped with completely sealed dual wound safety isolating transformers. Fuse failure lamps shall be of the neon type, with current limiting device.

Indicating lamps of the neon bulb type shall have a minimum service life of 20,000 hours. Double wound insulated transformer type indicating lamps where specified shall utilize lamps with a minimum life of 4000 hours. Lamps shall be easily removed or replaced from the front of the panel without the use of extractors. The body shall be reinforced thermoplastic while the lens cover shall be thermal resistant thermoplastic. Pilot light identification shall be engraved on the lens cover.

The Instrumentation section shall be segregated from other sections.

1.3.3.13 Installation

All assemblies shall be fixed true and level.

1.3.3.13.1 Free standing assemblies

Freestanding assemblies shall be securely mounted on plinths, which shall be flush with the bottom outside edge.

✓ Plinths

Plinths shall be constructed from minimum 5 mm thick steel and suitable to support the weight of the panel and shall be secured to the floor.

1.3.3.13.2 Wall mounted assemblies

Wall mounted assemblies shall be fixed via external lugs at the rear of the enclosure at easily accessible positions. The enclosure and fixings shall be suitable to support the total weight of the assembly without distortion.

1.3.3.13.3 Front access assemblies

Front access assemblies shall be fully maintainable and constructed from the front and arranged so that all normal operations, essential maintenance, replacement of any components and connection/disconnection of cables can be carried out from the front of the assembly including busbar maintenance and extensions.

1.3.3.13.4 Rear access assemblies

Rear access assemblies shall be arranged so that all normal operations are carried out from the front of the assembly, but essential maintenance, replacement of any components and connection/disconnection of cables may be carried out from front and/or rear of the assembly. Access to the rear of the panel shall be by means of hinged lockable doors.

1.3.3.13.5 Wiring Terminals

Cable terminations and space for terminations shall be suitable for the sizes of cable called for in the design, or shown in the drawings.

Terminal blocks shall be made of thermosetting melamine or polyamide material with a low tracking index and good flame resistance, tested to C above ambient temperature.

Provision shall be made for permanent labels to be applied to each terminal for identification purposes.

All terminals shall be marked in accordance with BS 5472.

All terminals for control wiring shall have provision for plug-in test spills and in addition be fitted with isolating links. Current carrying parts shall be made of tinned brass or copper.

Completely shrouded terminals of the tunnel type shall be used for cables up to 10mm².

The screw clamp connection shall be vibration proof, self-locking and suitable for clamping two conductors. Stranded cables up to 10mm² shall be terminated in copper or copper alloy ferrules. The ferrule shall retain all strands of the cable.

Terminals for cables in excess of 10mm² shall be of the compression cable lugs or proprietary makes of termination approved by the Engineer. The terminal and stud size shall be adequate for the current carried and the size of cable. Suitable insulating partitions and protective covers shall be provided. All cable terminals shall be labelled.

Cable lugs shall be of the annealed copper one-piece seamless construction type. Lugs shall be burr free and tin-plated to prevent corrosion. All crimping of lugs shall be done using proper crimping tools.

All auxiliary wiring except screened cables shall be connected to incoming/outgoing cables via insulated

terminal blocks, screw/screw type, clipped onto DIN rails. There shall be sufficient space on the DIN rail for future terminal blocks of not less than 10% or 5 Nos.whichever is the greater.

Wires shall enter terminals singly. Where multiple cables are to be shorted, external links shall be used. Plugs and fixed sockets for the application shall be provided for the termination of screened cables.All terminations shall be mounted at least 0.2m above the base of floor mounted assemblies.

All load terminals shall be suitable for the types and sizes of cables as specified in the drawings.

1.3.3.13.6 Batteries

Batteries and chargers for closing and tripping purposes, if specified shall be provided as separate remote assemblies. These shall comply with the separate Specification for batteries and charging equipment.

1.3.3.13.7 Floor Mats

Rubber floor mats of 6mm thickness and 1 metre width shall be provided for the complete length of allswitchboards and motor control centres, along the front and back where accessible for maintenance.

1.3.3.13.8 Circuit Diagrams

Circuit diagrams affixed to a wooden base and covered by clear transparency shall be affixed next to allfactory built assemblies. These circuit diagrams shall indicate the wiring schematics and control logicdiagrams. For distribution boards and control panels a laminated schematic fixed on the inside cover ofthe panel will be accepted.

1.3.3.13.9 Artificial Respiration Charts

Artificial respiration charts shall be affixed in all main switch rooms, and transformer areas and generator rooms.

1.3.3.13.10 Equipment Exposed to the Weather

All equipment exposed to direct sunlight and the weather shall be constructed from weather resistant materials like glass or aluminium. Plastics and other materials, which rapidly deteriorate when exposed to the weather, shall not be used.

1.3.3.14 Power Factor Correction

1.3.3.14.1 General

Supply and install automatic power correction equipment comprising a capacity bank with automatic switching in minimum step of 25kVar and combinations, suitable for connection into the Electricity Supply located in the main switch room.

1.3.3.14.2 Capacitors Capacitors shall:

- Comply with IEC 60831-1 & 2
- Be rated at 480 Volt 50 Hz
- Be capable of operating 1.1 x Un(8 hours over 24 h)
- Have losses - Dielectric loss < 0.2W/kvar, Power Losses 0.5W/kvar
- Operate within the following ambient temperatures (-)25 to 55 C
- Comply with an insulation level of 0.6 kV with a withstand voltage of 50 Hz. 1 minute 3kV.

- Be constructed of moralized polypropylene coils coated with thermosetting resin complete with discharge resistors.
- Have self-healing characteristics.
- Incorporate coordinated protection system (HRC + over pressure).

1.3.3.14.3 Automatic Power Factor Regulator

The automatic power factor regulator and capacitor bank shall:

- Have a rated output as indicated on the drawings to automatically correct the power factor to a settable lagging value in regulated steps of 25 kVar.
- Shall be housed in a floor standing sectional sheet metal enclosure for front and rear access IP54.
- Be painted in light

orange. The automatic

regulators shall:

- Be micro processor based.
- Have two (2) switching programs 1:1:1, 1:2:2.
- Have digital power factor indication.
- Incorporate manual by pass for switching capacitors on/off.
- incorporate number of capacitor banks connected indication.
- Incorporate built in alarm.
- Have adjustable time delay between steps.
- Cos 0 setting of 0.85 inductive to 1.05 capacitive.

1.3.3.15 Wiring Methods

All wiring shall be installed so that it can be readily renewed, repaired or relocated without affecting building finishes and construction.

Wiring for other systems, eg. MATV, Public address, telephone etc., shall be installed in a similar manner to light and power wiring in the same area.

The following wiring methods shall be used in the installation:

- Stairs Lighting : PVC insulated conductors enclosed within PVC Conduit cast into the wall/ceiling slabs.
- Plant rooms Lighting & Power : PVC insulated conductors enclosed within PVC conduit cast into ceiling/floor slabs. Surface conduits in lift motor rooms shall be of galvanized steel
- Other Internal Areas : PVC insulated sheathed conductors false ceiling.
- Lighting and Power : Space and within cavity walls.
- Exterior Lighting : PVC insulated conductors with Category A underground conduit.

1.3.3.16 Installation of Wiring

1.3.3.16.1 General

All cables

shall

- be run concealed unless specified otherwise. Exposed cables shall be run parallel to walls, floors and ceilings.
- be adequately fixed and supported with purpose made clips, cleats or saddles.
- be installed to permit adequate air circulation around each cable.
- be installed without any joints between items of equipment.
- be installed on the loop-in, loop-out principle without the use of connectors for subcircuit wiring.
- be installed so that they can readily be withdrawn for the purposes of relocation and/or rewiring.
- be loomed on the square grid form, using approved plastic straps within switchboards..
- be installed such that they are not bent through radii less than the minimum bending radii specified by the manufacturer
- be spaced apart to provide a gap of one cable diameter (minimum) between adjacent circuit or sub- main groups, where installed together over parallel routes.
- be fixed to permanent structural components of the building where the cables supply essential circuits, such as fire services, lifts, emergency lighting etc., Additionally, these cables shall be positioned above ducts, pipes and others building components which may become dislodged and cause interference to the cables.
- All main and sub-main cabling shall:
 - be run parallel to building lines. Cables of 100 metres or more in route length, shall have individual phase conductors transposed, at approximately one third positions along the route length, to completely rotate the phase configurations.
 - be supported on a system complying with clause “Cable Support System” except where specified otherwise.

1.3.3.16.2 PVC Insulated Conductors

Installation PVC Insulated Conductors shall:

- be enclosed within conduits or wiring ducts.
- NOT be drawn into conduit systems until the conduit run is complete, swabbed out and inspected by the Consultants.
- be installed on the loop-in system without the use of connectors.
- be jointed only at outlet or switch positions.

1.3.3.16.3 PVC Insulated and Sheathed Conductors

Installation PVC Insulated and Sheathed Conductors shall:

- NOT be installed in locations where they cannot easily be withdrawn for rewiring purposes.
- be enclosed within concealed conduit where run in rendered walls or concrete..
- be installed through suitably sized and bushed access holes positioned vertically or horizontally in

line where run within stud partitions.

- be secured in position by approved methods where installed in accessible locations.
- where run in accessible false ceilings, be clipped at maximum 2000mm centers to a permanent building structure. Cables shall be supported clear of ceiling tiles. Cables shall not be tied to duct work, sprinkler pipes etc..
- NOT be secured or clipped where installed in accessible locations such as cavities and stud partitions.
- be protected by steel conduits where installed in locations which are liable to mechanical damage and where specified herein.
- be installed using the loop in system without the use of junction boxes.
- be installed on cable trays (or other supports complying with clause CABLE SUPPORT SYSTEM) for single core conductors which form a circuit or sub main group.
- be installed in trefoil formation for single core conductors sized 90mm² or larger using purpose made clamps such that proximity effects in adjacent ferrous metals are minimized and equal reactance values between phases are achieved.
- Be fitted with a cable gland on all circular cable where they penetrate equipment enclosure.
- be fitted with a cable gland on all circular cables where they penetrate equipment enclosures.

1.3.3.16.4 Underground wiring

installation Underground Wiring shall:

- be installed over routes as agreed with the Consultants
- be laid at a minimum depth of 500mm below finished ground level.
- be enclosed in orange coloured PVC conduit fitted with the manufacturer's standard fittings where installed below roadways and paved surfaces.
- be enclosed within pipes where passing through the perimeter walls of buildings for a minimum length of one meter (1m) from the exterior of the building, and be sealed with compound to prevent the entry of moisture or vermin.
- be laid on a 75mm deep bed of salt free sand at the bottom of the trench (unless enclosed within conduit)..
- be covered with salt free sand after laying in a depth of 75mm above the top of the cables (unless enclosed within conduit)
- be covered with "Electric" bricks or slabs with a minimum overhand of 100mm over the edge of the outer cable(s) or covered with a 6mm thick orange coloured P.V.C. cable cover unless the cables are enclosed in rigid non-metallic pipe complying with BS 4607.
- be provided with continuous PVC marker tape in the trench at least 150mm above the cables and between 150mm and 300mm below finished ground level.
- be installed within trenches by using approved rollers to prevent damage to the cables during

installation (unless enclosed in conduit).

1.3.3.17 Electrical Low Voltage Cables

1.3.3.17.1 General

Unless otherwise specified all cables shall:

- be BASEC approved/comply with relevant British Standards.
- have copper conductor
- have stranded conductors
- be of minimum size 2.5mm² (subject to volt drop) for power, 1.5mm² for light and control

circuits. have insulation coloured as follows:

- | | |
|-------------------------------------|--|
| • Actives of single-phase circuits | Brown |
| • Actives of multi phase circuits | |
| • A phase | Brown |
| • B phase | Black |
| • C phase | Gray |
| • All neutrals | Blue |
| • Switch wires, control wires, etc. | as required but same colour for similar functions. |

1.3.3.17.2 PVC Insulated Cables

PVC Insulated shall

- be insulated with 0.6/1 kV grade PVC compound type V75 or higher.
- comply with BS 6346
- Fire retardant type

1.3.3.17.3 PVC Insulated & Sheathed

Cables PVC Insulated & Sheathed Cables

shall

- be insulated with 0.6/1 kV grade PVC compound type V75 or higher.
- comply with BS 6346
- have different colour sheathing for extra low voltage (32 Vac or 1156 Vdc maximum) circuits and/or fire services.
- Fire retardant type

1.3.3.17.4 MIMS Cables (MICC)

MIMS Cables shall:

- be 1000V grade (except 600V grade may be used for emergency direct current reticulation and control wiring.)

- have copper sheathing
- be P.V.C. served
- have magnesium oxide insulation
- be manufactured in accordance with BS 6207 with glands and accessories in accordance with BS 6207.

1.3.3.17.5 Flame Retardant Cable

Flame retardant cables used as an alternative to MIMS cables shall:

- Comply with IEC 502
- Comply with BNS 6387 and have the rating as specified by the Standard relevant to the
- Installation or CWZ (minimum) where Standard does not specify a rating.
- be approved by the Statutory Authorities having jurisdiction over the particular service.

1.3.3.17.6 PVC Insulated Wire Armoured and PVC Sheathed Cables

PVC Insulated Wire Armoured and PVC sheathed cables

- be PVC insulated with 0.6/1 kV grade PVC compound type V75 or higher
- Comply with BS 6346
- Have orange coloured PVC sheath.

1.3.3.17.7 Flexible Cords

- Be PVC insulated and PVC sheathed
- Comply with BS 6500

1.3.3.17.8 Cable Termination Lugs Cable termination lugs shall:

- be installed on ALL conductors except where tunnel or similar terminals which ensure that all cable strands are retained under the clamping screw are provided.

Copper to copper joints shall:

- comprise an approved clamp type cable lug with bolted connection to the conductor or crimp type installed with a ratchet type crimping tool.
- be copper
- be in accordance with the cable manufacturer's recommendations. Aluminium to aluminium joints shall be by one of the following methods:
- Compression method
- Select aluminium crimp lugs or tinned copper ferrules to suit the size and shape of the conductor
- select compression dies to suit the particular lug or ferrule;
- fill aluminium lug or ferrule with oxide-inhibiting grease:
- use a hexagonal die for stranded conductors;
- use an indent die for solid conductors and indent the lug or ferrule twice.
- Fusion weld method: Make joints by the fusion welding method with aluminium lugs,

using jointers experienced in this method. Protect the cable insulation from heat by fixing substantial heat sinks to the cable near the joint. After completion of the weld wire brush the joint and the file sharp projections smooth.

Provide a sample crimped lug cut in half for inspection, if requested.

Aluminium to copper connections shall be by the compression method specified in ALUMINIUM TO ALUMINIUM JOINTING using one of the following connector types:

- Bi-meal: Of the lug or pin type having a cast copper palm or pin, friction welded to an aluminium barrel section which is subsequently factory-filled with an oxide inhibiting grease.
- Tinned copper ferrule
- Cast electro-tinned aluminium lug: Bolt the palm of the lug to copper bus bar or terminal using a stainless steel bolt and nut with one large diameter stainless steel flat washer and one spring cup washer.
- Straight through joints (tee offs) shall:
 - have the minimum amount of insulation removed
 - have the complete joint wrapped with two layers of insulation, the first being a non hydroscopic film, the second being P.V.C. extending 100mm each side of joint.

1.3.3.17.9 Cable Makers Cable

markers shall:

- be installed over all underground wiring routes.
- comprise approved brass marker plates with directional arrow.
- be engraved or substantially stamped to indicate:
 - o the type of cable (electricity, Telephone, Controls, PA system) o
 - the depth below the surface. o the distance in meters to the next marker.
- be set flush in a circular concrete base, 200mm deep tapered out to 300mm diameter at the bottom
- be set flush to the surface in foot paths, roadways, paved areas etc., and protrude 25mm above other surfaces.
- be installed at positions:
 - o where the cable passes through external walls of a building o
 - where the cable changes direction (2 markers) o at 100m (maximum) intervals for straight runs.

1.3.3.18 Conduit - General requirement

Unless otherwise shown on the drawings, conduit systems installed in internal areas with plastered or similar finishes shall be concealed within the building fabric. In other areas the conduits shall be installed on the surface.

Conduits shall be installed in a neat and tidy manner. Conduits in or on walls shall run either horizontally

or vertically. Conduits on ceiling or roof structures or in slabs shall run either parallel with or perpendicular to the structural elements of the building. Conduit boxes and accessories shall be correctly to the face aligned.

Conduit runs in damp situations shall be arranged to be self- draining to specific drainpoints which shall consist of BS boxes but not boxes containing live terminations. All bends and sets shall be formed from straight conduit except where the installation makes normal factory made bends may be used. Where conduits cross movement joints expansion couplings shall be installed.

All conduit boxes not carrying lighting or other fittings shall be installed with a suitable cover fixed with brass or stainless steel round head screws.

Covers for external application shall have machined faces, and shall be provided with neoprene type gaskets. All conduits shall be free of rust patches or other defects on delivery and shall be protected from mechanical damage and weather when stored on site.

The metallic conduit system shall not be used as the sole means of earthing. A separate earth continuity conductor of suitable size shall be run inside the conduit, and bonded to the conduit system at both terminals. All conduits shall:

- be installed using the loop-in system (there shall be no tee-offs between outlets).
- be free from conduit fittings other than junction boxes, wall boxes, bends or couplings.
- be 20mm minimum diameter
- be circular in section. Oval conduits are unacceptable.
- be installed complete with fittings and draw wires before wiring of a particular section is commenced.
- be concealed from view by running in ceiling spaces, concrete slabs, wall cavities or chasing into rendered masonry walls unless otherwise specified.
- contain a maximum of two (2) circuits
- be arranged so that individual conduits are provided for light circuits, power circuits, Telecom wiring, fire alarm system wiring, low voltage wiring, emergency lighting wiring and communication system wiring.
- be placed above the bottom reinforcing bars where run in concrete slabs
- be set using approved type conduit benders which prevent flattening of the conduit, (Application of heat in bending conduit will NOT be permitted).
- be enclosed within the concrete and not in contact with the fill where installed in slabs poured on filling.
- be installed in a manner which will not necessitate penetration of damp courses or influence the entry of moisture into the building.
- be located below the thermal insulation where installed in ceiling spaces.
- be provided with draw-in boxes at 24m (maximum) intervals.
- terminate at:
 - o deep pattern junction boxes for ceiling outlets embedded in concrete.
 - o standard depth junction boxes for outlets above the false ceiling.
 - o wall boxes for all flush wall outlets and switches.

- be provided with a polypropylene draw cords where installed for future wiring or wiring by others.
- be fitted with a stamped metal label indicating their purposes and the area which they are intended to supply where installed for future wiring or wiring by others.
- be swabbed out to remove all moisture before installation of wiring.
- be fitted with a sealed cap to prevent moisture or obstructions entering the conduit before cables are installed.
- be fitted with draw in boxes and openings wherever necessary, but not less than every second direction change.
- be equipped with flexible couplings for 600 mm on either side where runs cross Constructional joints.
- be positioned within the centre of concrete slabs.
- be positioned within masonry walls or columns with a minimum of 25mm of cover
- be accurately positioned and aligned where they emerge from the concrete structure and fixed by fastening the up stands to approved rigid supports.

Steel Conduit

Conduits, bends and couplers shall comply with BS 4568: Part 1, BS EN 60423, and BSEN 500861. Conduit fittings and components shall comply with BS 4568: Part 2. The conduit shall be class 3 medium gauge unless otherwise indicated on the drawings.

Only galvanized accessories shall be used with galvanized conduit.

Particular attention shall be paid to the continuity of all conduits and fittings to avoid high resistance of any joints and connections. Earth continuity links of 2.5mm² green/yellow insulated copper wire shall be fitted at expansion couplings.

Conduits shall be installed at the maximum practical distance from cold water, hot water and gas pipes or other metal enclosed services. Where conduits have to run in close proximity to these services, the metalwork of the services shall be electrically bonded together and to the conduits with a bonding conductor. Clip-in conduit accessories shall be suitable for use with light or heavy gauge conduit. Box spouts and conduit couplers shall be fitted with a spring steel claw, which bites into the conduit.

Conduits shall be fixed at 1200mm (maximum) centers where surface run.

Where conduits connect to distribution boards, trunking, switch and fuse units, single and multiple switch boxes, etc, they shall be connected to the apparatus by means of a conduit coupling and hexagon male smooth bore brass bush. Conduit connections to trunking may alternatively be made via a terminal or through way box mounted on the trunking and connected to it by a smooth bore brass bush and internally threaded brass ring.

Where 'spout' type boxes are used, hexagonal lock nuts shall be employed to ensure a tight fit for the conduit. Where an exposed galvanized surface has been cut or otherwise damaged it shall be repaired by application of a zinc rich epoxy primer with a generous overlap on the existing sound metal coating. Exposed threads and connections shall be similarly treated. The epoxy primer shall be used strictly in accordance with the

manufacturer's instructions.

Conduit shall be bent or set cold without altering its section, using a suitable bending machine. The inner radius of any conduit bend shall be not less than 2 times the external diameter of the conduit. No more than two 90 angle bends shall be installed in any run of conduit without a draw-in box.

In damp and exterior situations or when fixing into concrete sherardized or cadmium plated screws or stainless steel screws in bronze inserts shall be used.

Interval of junction boxes to be maximum of

24m. Flexible Steel Conduit

Flexible conduit and adaptors shall comply generally with the requirements of BS EN60423 for packed construction, except that under no circumstances shall asbestos packing be used, BS EN 60423, BS EN 500861.

Adaptors shall be of the solid type in brass or zinc plated mild steel. The flexible conduit shall be PVC- sheathed.

Non-Metallic Conduit

All rigid non-metallic conduit and conduit fittings shall comply with the relevant parts of BS EN 50086, BS 6099, BS 4607 and BS 7671, BS EN 60423, BS EN 50086-1 & 2 Conduit for exposed surface installation shall be heavy gauge. Concealed conduit forcasting in shall also be of heavy gauge.

Conduit, fittings and accessories shall be of the same manufacture to provide a consistent appearance. The colour shall be as specified. Unless shown otherwise on the drawings, accessory boxes installed in plaster or similar finishes shall be steel to BS 4662.

Pliable conduit shall not be used where mineral oils or petrol are present. Screwed non-metallic conduit shall not be used unless specifically called for.

Boxes and extension rings shall be fitted with brass inserts for the securing screws and additionally boxes shall have an earthing terminal. All spouts on boxes shall be of the web moulded type. Adaptors shall be used to connect to boxes or other accessories not provided with spouts.

No inspection elbows, bends and tees shall be used. Manufactured bends shall not be used.

Bends shall be made using the correct size spring. Conduit sizes of 25mm and below may be set cold but all larger sizes shall be set hot. A pipe vice shall not be used during this or any other operation. The radius of any conduit bend shall not be less than 4 times the outside diameter of the conduit. Naked flames shall not be used directly to heat conduit.

Conduit with fractured or wrinkled bends is not acceptable and shall be replaced.

Joints shall be made in accordance with the manufacturer's recommended procedures.

Conduit ends shall be cut square and all burrs and sharp edges shall be removed. Care shall be taken to remove damp, grease, cement dust and oil from all faces of conduits and accessories prior to jointing.

Joints into couplers, adaptors and spouted fittings shall be made using a solvent adhesive approved by the maker of the conduit. Conduits shall be entered fully into box spouts and butted into couplers

and adaptors. Solvent adhesive shall be applied only to the faces to be jointed. The dipping of conduit or fittings into

solvent adhesives is expressly forbidden. All joints shall be watertight.

Where conduit crosses building expansion joints or where there are changes of temperature in C, flexibility of the conduit to cope with the associated movement.excess of 25 shall be achieved by a method approved by the manufacturer of the conduit.

Surface mounted conduit shall be fixed by means of non-metallic spacer bar saddles or purpose made clips. Conduit shall normally be supported at regular intervals in accordance with the Guidance Notes to BS 7671. Where ambient conditions C, the supports shall be regularly spaced.

Where luminaire are to be connected to a ceiling conduit system, metal conduit boxes shall be used. Fittings shall not be hung from the non-metallic conduit system. Metallic backboxes shall also be used for mounting all switches and socket outlets, unless the devicesand their fixing screws are provided with suitable means of earthing.

Testing

Continuity tests shall be made at the completion of the conduit installation and details ofthe test results shall be entered on the Inspection Certificate.

1.3.3.19 Trunking - General Requirements

All multi-compartment trunking systems shall maintain the stated segregation throughout, including all accessories.

Trunking shall wherever possible be mounted with the lid on the top. Trunking shall not be filled to more than 60% of its usable capacity. Where multiple circuits are installed in the same trunking each circuit shall be grouped together using a cable tie or tape at 1m intervals and distinguished by an identification label at 10m interval along the run of the trunking

Surface mounted trunking shall be run truly horizontal or vertical. Where these requirements cannot be met trunking shall run parallel to the building lines.

Manufacturers' standard fittings shall be used for all connections and changes of direction. Trunking shall not be cut or bent to form bends, flanges or attachments.

Gusset bends shall be used where shown on the drawings or wherever necessary to provide sufficient bending radius for the cables.

Site fabricated items shall not be

used. Steel Trunking

Trunking and connectors shall be manufactured in accordance with BS 4678: Part 1.

Trunking shall be manufactured from galvanized sheet steel in accordance with BS 4678 protection Class 3. The thickness of sheet steel shall be not less than 1.2mm for trunkings up to 50mm width and 1.6mm for trunkings up to 200mm width and 2mm for larger sizes.

Lengths of trunking shall be bonded to each other using copper links, suitably tinned or plated to prevent corrosion and not less than 12mm wide x 1.5mm thick, fixed with brassnuts, bolts and serrated washers. Links shall be supplied by the trunking manufacturer.

Turnbuckle type lid fixings shall be specifically designed to avoid trapping wires.

Partitions or dividers shall be of the same material and finish as the trunking. The method of fixing shall not cause any long-term corrosion or electrolytic action.

Connectors shall span the complete internal surface of the trunking and shall be designed so that the trunking sections mate with butt joints.

Horizontal trunking sizes exceeding 100mm x 50mm shall be supplied with cable separators with insulated pins at intervals not exceeding 2 metres.

Where any cutting or damage is caused during erection, the finish shall be made good. All burrs and rough edges shall be removed. Where any corrosion has occurred it shall be removed and the area treated with a rust-proofing agent. After this it shall be treated by the application of either a zinc rich epoxy primer and in the case of Class 2 finishes this shall be followed by a coat of colour matching paint. Any fixings used for securing or fitting shall not cause any long-term corrosion or electrolytic action. Black japanned fixing screws shall not be used. Where brackets are used they shall be constructed of mild steel angle or channel iron finished to the same standard as the trunking.

Connections to multiple boxes, switchgear and distribution boards shall be made with flanged units or bell mouths. The braid ends shall be folded, and sweated solid.

Expansion joints in long continuous runs shall be provided as recommended by the manufacturer.

Corrosion Protection

The cable trunking & accessories shall be of Hot Dip Galvanized (ISO 1461-1999) for installations in corrosive atmospheres both indoor and outdoor application. Sample Trunking & accessories / mounting accessories and supports should be salt spray tested according to ISO 9227 for > 500 hours. (*550 hours according to class 6 for Hot dip Galvanized surface as per ISO)

Hangers and Supports

Supports shall be constructed from proprietary framing system components. Unless specified otherwise all support system members shall be made of the same material as the tray or ladder.

All steel components shall be hot-dip galvanized to BS 729 after manufacture. Where an exposed galvanized surface has been cut or otherwise damaged it shall be repaired by application of a zinc rich epoxy primer.

1.3.3.20 Cable Tray and Cable Ladder. General Requirements

Cable Tray and Cable Ladder systems are intended for the support and accommodation of cables and possibly other Electrical equipment in Electrical/Instrumentation/Communication systems.

Design and Fabrication of Cable Trays / Ladders

The cable trays / ladders shall be fabricated according to the design specified by IEC 61537 and should be tested for Safe Working Load (SWL). The relevant details of SWL and the load chart with respect to SWL, supporting distance and the deflection should be according to the following chart.

Safe Working Load (SWL) with a span length up to 3 meters

Description	Side Height (in mm)	Width (in mm)	Span length (in meters)			
			1.5m	2m	2.5m	3m
			Permittee	Load (in kg/meter)		
Perforated Cable Tray	35	50 - 300	125	90	50	-
	60	50 - 600	150	100	50	-
	85	100 - 600	175	110	50	-
	110	100 - 550	185	130	75	60
Cable Ladder	45	200 - 600	180	140	100	55
	60	200 - 600	-	225	150	100
	110	200 - 600	-	310	200	140

Table 2.4 Safe Working Load (SWL) with a span length up to 3 meters

Safe Working Load (SWL) with a span length up to 10 meters									
Description	Side Height (in mm)	Width (in mm)	Span length (in meters)						
			4m	5m	6m	7m	8m	9m	10m
			Permitted Load (in kg/meter)						
Perforated Cable Tray for long span distance	110	200 - 300	160	110	75	-	20	-	-
		400 - 600	200	150	100	-	40	-	-
	160	200 - 300	230	180	140	100	70	-	-
		400 - 600	250	200	160	130	100	-	-
	110	200 - 300	160	110	80	40	-	-	-

Cable Ladder for long span distance		400 - 600	210	150	100	70	-	-	-
	160	200 - 300	230	180	140	100	70	-	-
		400 - 600	250	200	160	130	100	-	-
	200	200 - 600	-	-	300	250	200	140	100

Table 2.5 Safe Working Load (SWL) with a span length up to 3 meters

It is compulsory for the bidder to submit original manufacture's literature for SWL & type test certificates for the offered cable trays

Fabrication of Tray / Ladder and accessories at site and welding is not permitted. In unavoidable circumstances, if any cut or holes are made in the Trays/Ladder/Accessories, Zinc Rich Spray needs to be applied over the surface. The metal edge has to be protected by edge protection sleeves to avoid cable damage. Edge of the supports has to be protected with plastic END caps. Screwed connections and internal

fixing Devices should not create any damage to the cable when correctly fixed. Sudden or jerky motions shall not be used to tighten reusable screw connections.

Cables shall run in cable tray/ladder mounted horizontally or vertically on cable tray support system which in turn shall be supported from floor, ceiling, overhead structures, trestles, pipe racks, trenches or other building structures using mounting accessories

The magnetic shield insulation for cable trays without cover should be 20dB & with cover should be 50 dB. Cable Tray

The cable tray and all accessories shall be fabricated from sheet steel and has to be hot dip galvanized against corrosion confirming to ISO 1461-1999 for installations in both indoor and outdoor applications & should have a Base Perforation Class B according to IEC 61537. The cable trays shall be supplied in standard lengths of 3000mm and the width of the tray shall be as follows.

Width: 50, 100, 150, 200, 300, 400, 600mm.

Height: 50, 75, 100mm

All the cable tray accessories like Bend's, TEES's, Cross over's etc should be designed in accordance with IEC 61537 and shall be factory fabricated. The accessories shall be from the same material as of the tray and modular type, it should be connected with the trays by using fasteners. Typical details of trays, fittings and accessories.etc are shown in the enclosed drawings.

For Cable trays designed, tested and confirming to IEC 61537, thickness of cable tray should be according to the manufacturer's catalogue.

For locally fabricated and non tested trays, thickness should be 2.5 mm up to span length of 1.5 meter, 3 mm for span length between 2 to 3 meter and 4 mm for span length between 4 and 10 meter.

Cable ladder

The cable Ladder and all accessories shall be fabricated from sheet steel and has to be hot dip galvanized against corrosion confirming to ISO 1461-1999 for installations in both indoor and outdoor applications & should have a Free Base Area classification Y according to IEC61537. The cable ladders shall be supplied in standard lengths of 3000/6000 mm and the width of the tray shall be as follows.

Width: 200 to 1200 mm in multiples of 100

mm Height (Side rail height): 75,100 mm

Maximum rung spacing in the ladder shall be 300mm. The rung's should be made of C profiles suitable to fix cables by special metal clamps according to the drawing. The ladder shall be of riveted and foldable type for easy transportation and to avoid damage during transportation and storage. All the ladder accessories like Bend's, TEES's, Cross over's etc should be designed in accordance with IEC 61537 and shall be factory fabricated. The accessories shall be made from the same material as of the ladder and modular type; it should be connected with the ladder by using fasteners. The details of ladders, fittings and accessories .etc are shown in the enclosed drawing.

For Cable Ladders designed, tested and confirming to IEC 61537, thickness of cable Ladder should be according to the manufacturer's catalogue. For locally fabricated and non tested Ladder, thickness should

be 3 mm up to span length of 1.5 to 2 meter, 3 - 4 mm for span length between 2.5 to 4 meter and 4-5 mm for span length between 5 and 10 meter

Cover for Cable Trays

Cover for trays to protect the cable insulation from falling objects, water droplets, Harmful effects of ultraviolet rays and accumulation of dust. The cover shall be made either from Double Dip Galvanized Sheets. For Outdoor application, Double dip Galvanized material shall be used. The covers should be fitted properly to the Tray by using pre fixed and tested locks which ensure that covers are fitted rigidly to Tray. For outdoor application in high wind areas, additional cross over beadings to be used for fixing the cover on tray of width more than 500 mm.

Mounting Accessories (supports and Brackets)

The mounting accessories shall be fabricated from steel and has to be hot dip galvanized against corrosion confirming to ISO 1461-1999 for installations in both indoor and outdoor applications and should be of completely modular type.

All supports and Brackets should be factory made, hot dip galvanized after completing welding, cutting, drilling, other machining operations and tested according to IEC 61537 according to the arrangements in the enclosed drawing. The system shall be designed such that it allows easy assembly at site by using Bolts and Nuts. The main support and brackets shall be fixed at site using necessary brackets, clamps, fittings, bolts, nuts and other hard ware etc to form various arrangements required to support the cable trays. Welding of the components at the site shall not be allowed.

Corrosion Protection

The cable tray / ladder/accessories shall be of Hot Dip Galvanized (ISO 1461-1999) for installations in corrosive atmospheres both indoor and outdoor application. Sample tray / ladder / accessories / mounting accessories and supports should be salt spray tested according to ISO 9227 for > 500 hours. (*550 hours according to class 6 for Hot dip Galvanized surface as per ISO). Special considerations to be done against sea breeze/ salty environment.

Testing and Certification

Cable tray /Ladder bend, T Bend, cross, and all supports are to be tested for Safe Working Load (SWL), deflections, Impact resistance, Salt Spray & Electrical continuity test according to IEC 61537. The cable tray/ladder should not deflect more than 1/100th of the span length at SWL in Mid span and the transverse deflection of all mounting accessories at SWL shall not exceed 1/20th of the length. The cable tray / cable ladder should be tested up to 1.7 times SWL at minimum and maximum room temperature. The temperature classification of cable tray system should be - 5 to + 150°C.

**** All required test certificates mention above to be submitted with the tender**

Hangers and Supports

Supports shall be constructed from proprietary framing system components. Unless specified otherwise all support system members shall be made of the same material as the tray or ladder.

All steel components shall be hot-dip galvanized to BS 729 after manufacture. Where an exposed galvanized

surface has been cut or otherwise damaged it shall be repaired by application of a zinc rich epoxy primer. Plastic end caps shall be fitted to exposed support channel ends in accessible positions and additionally elsewhere as specified.

Full details, with illustrations, of all supports and fixing devices shall be submitted before any orders are placed or manufacturing work put in hand. All supports and fixing devices shall have a factor of safety of not less than four.

The use of rag bolts, indented bolts, foundation bolts or similar fixings requiring grouting shall not be permitted.

Where supports have to be carried on structural steelwork, they shall be attached to the steelwork by means of girder clips, beam clamps or other proprietary attachment devices not requiring drilling or welding of the steelwork.

Transits and Fire Stopping ETC

Where proprietary cable transits are shown on the drawings they shall be installed strictly in accordance with the manufacturer's recommended procedures. Where cables pass through walls, floors, or fire partitions, sleeves shall be installed to facilitate installation and subsequent withdrawal of the cable.

Sleeves through building fire compartmentation walls and all floors shall be heavy-gauge steel. Sleeves through non fire-rated walls, ceilings, partitions and the like, shall be heavy gauge PVC.

1.3.3.20.1 General

The installation and components shall comply with BS 7671 and the Guidance Notes published by the IEE. Cables shall be delivered to site with the manufacturers' seals, labels, or other proof of origin intact. Such labels and seals shall not be removed until the cable is required for use and shall be retained for inspection. Cables shall be handled, terminated and installed in accordance with the cable manufacturer's recommendations. The technical advice of the manufacturer's specialists shall be followed if any special conditions or unusual circumstances exist.

Once a cable has been drawn off the drum, it shall immediately be laid in position. No cable shall be left lying on the surface after removal from the drum for more than the minimum practicable time. During installation no cable shall be bent to a radius smaller than the minimum recommended by the manufacturer. All cable lengths stated on the drawings are for design purposes only and shall not be used for Tender or construction.

Unless otherwise specified 3-phase groups of single-core cables shall be laid in trefoil formation and touching each other.

Cables shall be suitable for their environment and shall be certified by the manufacturer as such.

Unless otherwise indicated on the drawings, underground cables shall be installed in ducts where entering buildings or traversing railways, roads or other paved areas likely to be subject to vehicular traffic and shall be buried direct in the ground in all other locations.

Where cables and accessories are referred to as 'LSF', this shall be taken to mean that they have a low emission of smoke and corrosive gases when affected by fire. Where no applicable British

Standard exists for accessories the LSF materials used shall meet the emission requirements given in BS 6724 for cables.

Cables to BS 6724 shall not be installed in ducts or buried directly in the ground without the written approval of the cable manufacturer.

Installations in Hazardous Areas shall comply with the relevant parts of this Specification.

Cables jacks, cable drum axle, tripod, block and tackle, cranes, rollers, and wire stockings and other accessories necessary for the proper care and handling of the cable shall be utilised. All barricades, lamps, road danger notices and road boards shall be installed before work commences.

Where work is being carried out beside any public road warning signs must be erected. The form, placing and height of the warning signs must comply with the latest Road Traffic Ordinance Traffic Sign Rules.

Where it is necessary for any trench or pit to be left open overnight red warning lanterns must be placed at each end and at intervals not greater than 10 metres. In built - up areas barricades must be erected along the length of the cable trench or pit in addition to warning lanterns.

When in the course of the Works, obstructions are encountered which necessitate diversion of, or alterations to electric, water or sewerage installations, telephone cables or other underground works, or alterations to buildings or foundations or when conditions necessitate the adoption of a special form of trench, instructions shall be sought.

Care for Cables

Great care shall be exercised at all times to avoid damage to a cable. Drums must not be dropped and must only be rolled smoothly in the direction of the arrows on the drums.

At no time should the cable be twisted nor kinked nor should it be bent more than is absolutely necessary to handle the cable. The radii of bending must never be less than 12 times the overall diameter of the cable up to 50mm in diameter or 20 times the overall diameter of the cable greater than 50mm in diameter.

When running out the drum must be mounted on firmly supported jacks and the cable pulled off the bottom of the drum. The pulling rope must be attached to the cable by a wire stocking of the correct size with a swivel, if required.

After any cable has been laid and until the whole of the cables to be laid in a trench have been covered with their protective covers, no sharp metal tools such as hoe or spades shall be used in the trench or placed in such a position that may fall into the trench. Rollers used during the laying of cables shall have no sharp projecting parts liable to damage the cables.

The ends of the cables shall not be left exposed to water, dirt and foreign material, and shall be sealed with heat shrink end caps.

Labelling

Except in the case where it is terminated in full view onto a clearly labelled switch, starter, distribution board or similar piece of apparatus or onto a motor or other item of equipment the function of which is evident, every cable end shall be provided with one of the means of identification listed below. In particular, this requirement shall apply to all cables terminating on the back, or in the base, of a cubicle type or similar

switchboard or control panel and in any other case where the function of the cable is not immediately obvious.

The means of identification shall be one of the following:

- An engraved plastic or brass label securely screwed to the cable-sealing box.
- A stamped or engraved plastic, brass or aluminium label securely tied to the cable close to the sealing box with galvanized iron or tinned copper binding wire or plastic cable ties.
- PVC sleeve markers threaded onto a PVC carrier strip fastened to the cable with cable ties.
- Stainless steel sleeve markers threaded onto a stainless steel carrier strip fastened to the cable with stainless steel cable ties.
- Printed labels in transparent plastic holders fastened to the cable with cable ties.

Unless specified otherwise the means of identification shall give the cable size, number of cores and function together with the cable reference number if one has been allocated.

The cores of all control cables shall be individually identified, at terminations, by means of plastic ferrules bearing indelible characters, in accordance with the numbering on the relevant wiring diagrams.

Cables Laid Direct in Ground

Trial holes shall be made at 50m interval and at all change in directions, and will be measured in the run, unless backfilled prior to the installation of the cable. Detailed records of each trial hole shall be recorded during excavations. Details to include but not limited to the following:

- Plan view of trench and utilities found.
- Cross section of trench and utilities found
- Survey points and elevation of each service shall be clearly noted.

Cable Installation - Depth

Unless otherwise indicated on the drawings, cables buried direct in the ground shall be laid at a depth such that the vertical distance from the top of the upper most cable to the ground surface is not less than 750mm for LV cables and 900mm for MV cables.

Cable Installation - SPACING

Unless otherwise indicated on the drawings, the spacing between cables run in the same trench shall be not less than the values given in Table 2.6.

Type Of Service	Lateral Spacing (mm)	Vertical Spacing (mm)
LV cable. LV cable	50	300
LV cable. HV cable	300	300
HV cable. HV cable	300	300
LV cable. communications cable	300	300

HV cable. communications cable	300	300
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Table 2.6: Cable Installation: Spacing

Cables shall, in general, pass below all intersecting piped services, which cross the cable route, unless this would mean the cables being installed at a depth of more than 2 metres. Where cables are laid direct in ground which is or may be liable to subsidence they shall be 'snaked' from side to side of the trench to minimize the risk of the cable coming under tension as the result of such subsidence.

Cables shall be 'snaked' from side to side of the trench for a distance of 3 metres on each side of buried joints to avoid any risk of mechanical tension in the joint, and for a distance of 3 metres in advance of entries to draw-pits, buildings, or other fixed structures.

Trenches and Backfill

The cable routes shown on the Drawings are indicative only. The exact location of each trench shall be approved on site. Trenches shall be kept as straight as possible and each trench shall be excavated to an approved formation and dimensions and shall have vertical sides which shall be timbered where necessary so as to avoid subsidence and damage.

The bottom of each trench should be firm and of smooth contour. Any turf removed should be cut and stacked for reuse in a manner such that it can be watered as necessary.

The material excavated from each trench shall be placed so as to prevent nuisance or damage to adjacent hedges, trees, ditches, drains, gateways and other property or things.

Excavated materials shall be stacked on the far side of the trench from the road way so as to avoid undue interference with traffic. Where, owing to traffic or other consideration this is not permissible, the excavated material shall be removed from the site and returned for refilling the trench on completion of laying. Surplus material shall be disposed off site.

1 For single-core cables this shall be the distance between the groups of cables, not between the cables in a group

Cables shall not be laid direct in the ground if any corrosive agent is present.

Before cable laying is commenced, all cable trenches shall be drained, the bottoms graded and tamped, and all loose stones and similar debris removed.

In order to facilitate the re-use of excavated material for road foundation and surfacing, the excavated material shall be separated into hard road metal, turf, soil and other materials.

The trench excavation and filling- in shall be so executed that all walls, roads, sewers, drains, pipes, cables, structures, places and things shall be reasonably secure against risk of subsidence or injury.

Where a change of level is necessary, the bottom of the trench shall slope with a gradient not exceeding 1: 5.

The trench shall be kept dry and all necessary de-watering pumps made available before commencing excavation

Unless otherwise agreed, provision shall be made during excavation and until interim restoration has been completed, for reasonable access of persons and vehicles to property or places adjacent to the route.

Except in cases where cable trenches have been excavated in material which is completely free from flints, boulders, large pebbles or debris, all cables shall be laid on a compacted level bed of salt-free sand or selected soil having a minimum thickness of 100mm after compaction, measured from the bottom of the trench to the bottom of the cable.

All cables shall be covered with a layer of salt-free sand or selected soil having a thickness such that the cover over the top of the cable is not less than 150mm, after compaction of the material.

Where the drawings provide that cables shall be installed in two tiers in the same trench, the first tier of cables shall be covered with sufficient salt-free sand or selected soil, well compacted in 100mm layers, as will give a firm level bed for the second tier not less than 300mm above the tops of the cables in the first tier. The second tier of cables shall be covered as described above.

Trenches shall be available for inspection prior to being backfilled.

Cables laid in trenches shall be covered with backfill and warning tapes, Tiles as per the approved shop drawings.

While the trench is being backfilled, all large or sharp stones or other debris shall be removed from the fill material.

✓ Markers and Covers

Marker posts and slabs shall be reinforced concrete. Samples shall be submitted for approval.

Marker posts shall be installed at intervals of not more than 50 metres along all underground cable routes, at all joint positions, at all changes of direction and at both ends of road and rail crossings, except where such posts are likely to cause an obstruction to vehicles or pedestrians or to be liable to damage. In such cases marker slabs shall be used. The marker shall be 600mm x 600mm x 100mm thick mesh reinforced concrete slabs.

Marker posts and slabs shall bear the inscription in clearly legible lettering as appropriate. The letters shall be approximately 100mm high and 75mm wide overall with strokes 12mm wide and 6mm deep. Where specified cables shall be protected by a continuous layer of proprietary interlocking concrete or earthenware of such a width as will extend for at least 50mm on each side of the cable.

All cable covers shall comply with the impact requirements of BS EN 2484. Concrete cable covers, if more than 300mm in length, shall be suitably reinforced. All cable covers shall bear on their upper surface a permanent warning legend. The size of covers shall not be unduly large and should be able to be lifted easily by one worker.

All cable covers shall be placed so that the underside is not less than 100mm and not more than 150mm above the top of the cable.

Cables buried direct in the ground shall additionally be indicated by a 100mm width continuous strip of brightly coloured plastic tape, or wire mesh reinforced plastic, bearing an appropriate legend lay at a depth of 300mm below the surface.

Where HV and LV cables run in the same cable trench, the HV cables shall be protected by an independent run of cable covers.

Draw-in pits

Where shown on the approved drawings cable joints shall be enclosed in a permanent joint chamber. Cables within draw-in pits shall be adequately and permanently supported in cable cleats, clips, saddles or hangers, where necessary fixed to supplementary steel work. Where such cable supports interfere with cable pulling operations, they may be removed temporarily provided that adequate interim means of support are placed in position.

✓ Entries into buildings

Cable entries to buildings shall be sealed by one of the methods listed below:

- A pourable gypsum compound or polymeric sealant
- A gun applied elastic sealant
- An expanding polyurethane foam sealant.

Seals shall be formed in accordance with the manufacturer's recommendations. A written copy of such recommendations shall be provided to confirm that the sealant is suitable for the proposed use and is compatible with the duct and cable sheath materials.

Alternative sealing methods may be offered for approval.

✓ Crossing of culverts

Where it is necessary to cross drains or similar obstruction the cable shall be drawn into pipe sleeves. The pipes shall be supported at each end in a concrete block and shall project beyond the blocks into the ground for a distance of at least 750mm.

✓ Cables Installed In Air

Cables shall be installed in the manner indicated on the drawings. Cables run on the surface shall be run in a neat and tidy manner.

Cables shall be separated from water, gas, and other piped services by a distance of not less than 150mm unless the circumstances of the installation make this impossible.

Cables fixed to cable ladder/Trays shall have clips or saddles spaced at the following regular

intervals: Overall diameter of cable (mm)	Fixing centers (mm)	
	Horizontal	Vertical
Up to 9 inclusive	250	400
Above 9 up to 15 inclusive	300	400
Above 15 up to 20 inclusive	350	450
Above 20 up to 40 inclusive	400	550

For cables of larger diameter the manufacturer's recommendations shall be followed.

Where cables have to deviate to pass obstructions, or where sagging may otherwise occur, the spacing of cable supports and fixing devices shall be reduced below the maximum specified above.

Cables shall additionally be fixed 150mm on either side of a set or bend.

Single-core cables laid in trefoil shall be secured using purpose made trefoil cleats. Single-core cables laid side by side shall be individually secured using non-ferrous cleats. At any change of direction the maximum spacing of the cleats shall be reduced to 300mm. Non-metallic cleats used for LSF cables shall be of LSF material.

Unless indicated otherwise on the drawings, multi-core cables installed on the upper surface of cable trays or ladders shall be installed in a single layer and secured with stainless steel cable ties. Where cables are bundled into groups the ties shall restrain all the cables in the group.

Where trays or ladders do not directly support cables, for example on vertical runs, load bearing cable cleats or saddles shall be installed. Cable cleats and saddles shall be compatible with both the tray or ladder finish and cable sheath.

On multiple cable runs cables may be supported in either multi-way cable fixing racks or groups of single fixings.

Where cables are cleated to ladders on alternate rungs, such that the cables are suspended above the intermediate rungs, or wherever the weight of the cables is not supported at each rung of the ladder, calculations shall be provided to demonstrate that the maximum loading per rung is not exceeded.

Cable saddles and clips shall be fixed to the cable tray as follows:

- Building fabric - brass round head screws and fibrous or approved plastic plugs.
- Galvanized trays in damp or wet conditions - zinc coated roundhead screws, nuts and washers.
- All other cable trays, including plastic coated tray - brass roundhead screws, nuts and washers.

Where cables pass through walls, floors, or fire partitions, the installation shall be in accordance with the relevant part of this Specification.

Cable Glands

Unless otherwise indicated on the drawings or bills, cable glands shall be installed at all entries into switchgear, terminal boxes or other enclosures.

Holes cut in gland plates, adaptable boxes and other equipment shall be correctly sized for the gland to be installed such that a minimum of free play exists between the gland body and the cut metal. Paint or other finishes around the whole periphery shall be removed and the metal thoroughly cleaned before the gland is installed.

Cable glands shall comply with BS 6121 and shall be of a type appropriate to the type of cable being terminated.

Compression glands installed externally shall be classified IP66 and be provided with close-fitting PVC or PCP shrouds.

Where cables have a metallic inner sheath the gland shall have an electrical bond for the inner sheath. Unless otherwise specified in the drawings, cable glands for use with steel wire or steel tape armoured cables or unarmoured power cables shall be brass.

Cable glands for use with aluminium strip or aluminium wire armoured cables shall be tin-nickel plated brass. Alternatively, they may be aluminium provided that this will not be incompatible with other materials with which they may be in contact.

Locknuts and earth tags shall be of the same material as the cable gland.

Cable glands for use with unarmoured flexible cords with conductors not larger than 2.5mm² may be of polymeric material

Where specified on the drawings, glands shall have an integral earth stud for connection of a bonding cable. The armouring and metallic sheath, if any, of the cables shall be solidly bonded to earth via the cable gland by means of a copper conductor of section not less than that required by BS 7671, subject to a minimum section of 2.5mm². Where glands do not have an integral earth stud the conductor shall be connected to the cable by means of an earth tag installed under the locknut of the gland.

Unless otherwise indicated on the drawings the armouring of single-core cables shall be bonded at both ends of the cable. Single-core cables shall not pass separately through gland plates made of ferrous materials.

✓ Terminations

Conductors of 25mm² or greater cross-sectional area shall be terminated with tinned compression lugs. Conductors of 16mm² or less may be terminated with cable lugs or screw clamp terminals. Pinch screw terminals may be used for conductors' not larger than 6mm², unless the terminal forms part of a component or equipment defined elsewhere in this specification. All cable lugs shall be fitted with a colour coded PVC shroud. Where cables are to be terminated directly on motors or apparatus subject to vibration, a suitable expansion loop shall be formed in the cable immediately prior to the termination.

Any loop shall be formed such that the two sections of cable do not touch at the point of crossover.

Where the specified cables are too large to be terminated directly into a motor or apparatus subject to vibration, or where otherwise indicated on the drawings, the cable shall terminate in a junction box or isolator mounted adjacent to the apparatus. The final connections shall be made with single core cables run in flexible conduit. On circuits where the cables have been sized for voltage drop, these single core cables may be selected on current rating. A separate protective conductor shall be installed.

Low Voltage Cables

✓ Low Voltage Power Cables

Cables shall comply with BS 5467, BS 6346 or BS 6724 as specified in the drawings. The outer sheaths shall be in black colour, which are anti termite treated and embossed with the make, type and size.

Where armouring is not specified and there is no British Standard fully applicable then the cables shall comply in all other respects with BS 5467, BS 6346, or BS 6724 as appropriate. Full details of such cables, including relevant manufacturing standards, shall be submitted for approval.

The core insulation shall be coloured as follows:

Number of cores	Identification
-----------------	----------------

Single-core	Brown or Blue
Two-core	Brown, Blue
Three-core	Brown, Black, Grey
Four-core	Brown, Black, Grey, Blue
Auxiliary and control cables	Black with contrasting numbers

✓ Small Wiring Cables and Flexible Cords

The type of cable and the installation methods shall be as indicated in the drawings.

Cables shall be installed on the 'loop in' basis and joints between terminal points will not be permitted. A maximum of three conductors only shall be connected to any one terminal.

Connections to cables shall only be made in fittings, accessories or equipment enclosures.

PVC cables to BS 6004, LSF cables to BS 7211 and rubber cables to BS 6007 shall not under any circumstances be run underground.

Cables shall not be installed where the ambient temperature is likely to result in the conductor temperature exceeding the limiting temperature of the insulation.

✓ Single-Core Cables

All single-core non-sheathed cables shall be drawn into a continuous protective enclosure of conduit or trunking installed in accordance with the requirements of this Specification.

Cables shall be protected throughout their entire length except where they are installed within the enclosures of electrical apparatus or equipment.

Single-core cables installed in conduit or trunking shall have stranded conductors with aluminium cross-section of 1.5mm². PVC cables shall comply with Table 1a of BS 6004.

Where specified as LSF, cables shall comply with Table 3 of BS 7211.

Where trunking is installed with the lid on the side or bottom, the wiring shall be restrained by cable retaining straps supplied by the trunking manufacturer. These shall be fitted at intervals not exceeding 1m. The maximum number of cables drawn into any one conduit or trunking shall not exceed those allowed by the relevant regulations, Drawings and the Guidance Notes.

Where circuits are wired in single-core cables a separate circuit protective conductor shall be installed. Metallic conduit and trunking systems shall not be used as the sole circuit protective conductor.

Where expansion couplers are used allowance shall be made in the length of the conductors to accommodate any expansion.

The whole of the conduit system in any particular section shall be completed and free from any dirt or loose matter before cables are drawn in.

✓ Fire Resistant Cables

Cables specified as fire resistant shall be certificated by the Loss Prevention Certification Board (LPCB). Cables shall be tested to BS 6387 and meet the requirements of category C.W.Z or as specified. Cables to BS 7629 shall be Type B.

Fixings shall be able to withstand the fire for the same duration as the cable. The type of fixings employed shall be consistent throughout the installation.

Cables shall be installed in continuous runs without intermediate joints.

✓ Testing

As soon as is practicable after the completion of installation and jointing of the cables or of any usable group of such cables the tests to prove compliance with this Specification and with the requirements

of BS 7671 shall be carried out.

An earth continuity test shall be carried out to verify that the cable armouring and metal sheath, if any, have been properly bonded to earth.

Phase-rotation and phase-correspondence shall be tested to prove that the cables have been correctly connected.

For power cables a voltage test of 15 minutes duration shall be applied in accordance with the relevant British Standard:

BS 5467: Appendix B8

BS 6346: Appendix

B8 BS 6724:

Appendix B8

Proposals on the appropriate test in respect of other types of cable shall be submitted for approval.

✓ Phase Identification

The phase identification for main cables and connected branch cables shall be clearly recognized from an external viewing. Suitable methods such as marking, sticking of colour tape or emboss line on the surface of cable shall apply.

Mineral Insulated FR/LZHF Cable

✓ General

In the event of fire the cables shall maintain the active safety of electrical circuit integrity at the operating voltage. They shall also have passive safety of flame retardation with a Limiting Oxygen Index of more than 40%, low toxicity, low fire load, low smoke and zero halogen.

Cables shall be suitable for installation in wet or dry locations, in conduits, Concealed, free on the air, on cable trays or supports and direct underground. Cables that pass the system integrity tests shall be preferred. The cables shall be tested with DIN 4102: Part 12 which assesses the ability of enclosure systems in maintaining the function a cable system, for a period of time when exposed to a fully developed external fire according to ISO 834 time-temperature curve.

✓ Cable Construction

Flexible Mineral Insulated Copper Cables shall be manufactured according to relevant standards similar to BETA flam from Studer Cables or equivalent.

Flexible cables shall have the copper conductors wrapped with glass mica composite tape flame barrier (with special resin bonding material) and be insulated with a non-melt cross linked flexible mineral insulation and mineral sheath, similar to Betaflam Flexible MI cables or equivalent.

Mechanical properties and termite repellent Armour

Metal Armouring (where necessary for stronger mechanical protection, harmonics/EMCscreening and rodent/termite resistant)

The armour shall consist of two overlapping steel tapes for multicore cables. For single core cables copper or aluminium tape armour shall be used.

The armour shall be designed to total enclose the cable maintaining 30% overlapping. This is to prevent termites from penetrating any armouring gap.

No toxic materials shall be used for the purpose of termite or rodent repellent.

The cables shall have bending radius of no less than 8 times of the cable diameter for single core cable and 6 times for multicore cable. Insulation materials shall be suitable for continuous operation at 110 °C for 20,000 hours according to IEC 216 and all cables shall be tested to the following international standards. Test certificates and reports shall be submitted to substantiate the compliance to the following international standards.

- ✓ BS 6387 Category CW and Z
- ✓ DIN VDE 4102 E30 Part 12
- ✓ IEC 331
- ✓ Bomba Requirement
- ✓ Electrical System Integrity Test
- ✓ DIN VDE 4102 E30 Part 12
- ✓ Flame Retardant
- ✓ IEC 332-3
- ✓ Category A - High Density Cabling
- ✓ Category B - Medium Density Cabling
- ✓ Category C - Light Density Cabling
- ✓ Limiting Oxygen Index
- ✓ ASTM D 2863
- ✓ Insulation $\geq 40\%$ O₂
- ✓ Sheathing $\geq 40\%$ O₂
- ✓ Smoke Obscuration
- ✓ DIN VDE 0472-816
- ✓ IEC 1034-2; the light transmission value of greater than 84% shall be maintained
- ✓ Halogen Content and Toxicity

Cables shall comply with IEC 754 - 2, and also shall not emit toxic gases and contain very low organic contents. Complying with DIN VDE 0472 - 813 and NES713/NFC 20 -454

- ✓ Fuel Element

To minimise the generation of heat if subjected to fire, the insulation and sheathing material must not have a heat of combustion greater than 7,700 Btu/lb or 13 kg/gram.

- ✓ Short Circuit and Overload Resistance

Cables shall be able to withstand a short circuit temperature of 280°C for 5 seconds.

- ✓ Quality Control

Companies manufacturing cables shall be accredited to the ISO 9001 quality assurance standards and is listed with VDE Testing and Certificate Institute.

Thus, all the products supplied must carry VDE Certification mark.

- ✓ Installation

Cables must be securely fixed with steel or copper cable clips or ties (non-magnetic steel for single core cables) to inclined or vertical trays. Steel expanding securing bolts or percussion fastening systems is recommended.

Termination by crimping is recommended. Flameproof glands are not necessary unless dictated by the class

of hazardous location. Metal glands or close fitting metal bushes are recommended for all cable entries. compliance.

cables installed in areas where they may be subjected to mechanical damage will be protected with suitable mechanical protection. Steel conduit or metal tray covers are recommended.

✓ On Cable Tray or Ladder

Cables should be secured with metal fixings such as stainless steel cable ties, strapping or cable clamps with the following minimum recommended fixing distances: -

Vertical, Inclined or Unsupported

- For cables or cable bunches of diameter $\leq 25\text{mm}$ fix every 600 mm
- For cables or cable bunches of diameter $> 25\text{mm}$ fix every 300 mm
- Horizontal where supported by the ladder or tray - Fix every 1,000mm.

Trays/ladders should be fixed to the fire rated elements of the building structure using steel expanding bolts or similar system not incorporating flammable materials such as nylon.

Trays and bolts should only be loaded to 50% of the manufacturers' recommended maximum.

✓ Steel Conduits

Conduits should be secured with metal saddles (generally galvanised steel) using steel expanding bolts or similar system not incorporating flammable materials such as nylon.

1.3.3.21 Site Tests

1.3.3.21.1 Assemblies

All assemblies shall be subjected to the routine tests as defined in BS EN 60439 after installation on site. Test Certificates shall be provided.

1.3.3.21.2 Functional units

All functional units shall be checked for correct mechanical operation.

1.3.3.21.3 Protection circuits

All protection circuits in which relays are used shall be tested for correct operation by secondary injection of test currents. This shall be carried out at currents equivalent to overload, short-circuit and earth fault conditions.

1.3.3.21.4 Current transformers

Protection circuits using current transformer (CT) operated relays shall be tested by primary injection of current to prove the transformer ratio, and polarity.

1.3.3.21.5 Commissioning

Following the satisfactory conclusion of inspections and tests on completed sections of the Works, each switchgear assembly shall be duly commissioned and left in full working order. Contractor shall take proper approval from Client consultant prior to handover. The term 'Commissioning' shall be deemed to include:

- The energizing of functional device circuits and equipment, which have previously been inspected, tested, found to be satisfactory and capable of being energized with complete safety.

- The starting up of all electrically powered plant and equipment, including that supplied and installed under other contracts.
- The verification of the performance of each switchgear assembly relative to all such plant and equipment by carrying out, where required, of further tests and the making of all necessary adjustments so as to obtain optimum performance.
- The proving of all interlock operations in all possible combinations and the operation of all control systems, metering and indications to meet the performance requirements specified.

1.3.3.22 Thermographic Survey

Thermal image scan for MCC panels under full load conditions shall be done by contractor before the hand over.

1.3.3.23 Inspection, Testing and Commissioning

1.3.3.23.1 Works Tests

All assemblies shall be tested in accordance with the requirements of BS EN 60439, plus requirements of associated standards. The tests shall include:

- Insulation and continuity test
- Dielectric test - 3kV for 1 minute
- Primary injection tests to verify settings of current tripping devices.
- Check of clearances and creepage distances.
- Physical inspection of the assembly and finishes
- Verification of CT polarity and ratio
- Mechanical operation, Control interlock, and functional tests
- Earth continuity tests

1.3.3.23.2 Type tested assemblies

Where TTAs are specified, certification shall be provided for all type and routine tests to BS EN 60439.

1.3.3.23.3 Partially type tested assemblies

Where PTTAs are specified, compliance with the test requirements of BS EN 60439 shall be either by type testing or by extrapolation from type tested assemblies or individual parts of similar, representative construction. Verification of the Type Testing Certification or the appropriate extrapolation calculations shall be provided. Certificates shall also be provided for routine tests in compliance with BS EN 60439.

Calculation from first Principles for Temperature Rise and short-circuit strength will not be acceptable. Verification of short-circuit withstand strength is not required for assemblies having A-rated PSSC not exceeding 10kA or those protected by current limiting devices with a cutoff current not exceeding 15kA. Verification of short-circuit withstand strength is not required for auxiliary circuits connected to transformers whose: rated power does not exceed 10kVA for a rated secondary voltage of not less than 110 V, OR Rated power does not exceed 1.6kVA with a rated secondary voltage of less than 110V, and whose relative short-

circuit voltage is not less than 4%.

Works tests shall include inspection of all wiring and a complete electrical functioning test.

Protection relays shall be tested by primary current injection with currents equal to overload, short-circuit and earth fault conditions.

1.4 Lightning Protection System

1.4.1 Preliminaries

Lightning Protection System (LPS) is to protect structures including their installations, contents, persons & services connected to the structure against direct and indirect effects of Lightning. The LPS shall be in accordance with IEC 62305 & all the component used in the system should be tested to IEC 62561 on third part laboratory. The protection in detail shall include the following;

1.4.2 Protection of the structure against direct flash

Protection of human beings inside and designated areas such pathways outside the building.

Protection of all services connected to the building and protection of electrical and electronic equipments inside the building.

1.4.3 Structural Protection

The structural protection consists of Air termination, down conductors and Earthing. Special care should be taken for protecting corners, edges and parapet of the building.

Complete parapet should be protected by running horizontal air termination conductor. The air termination material shall be minimum 50 mm above parapet wall. In case of metal handrails running along the parapet wall or parapet covered with metal facade, air termination is not required, but this hand rail/facade must be connected to the LPS at minimum 2 places and at every 10 meters.

The flat terrace should be covered by horizontal air termination conductor in the form of a grid. This air termination conductor should be minimum 50 mm above the terrace and should be supported at every 1.0 meters. In case of metal roof, the air termination conductor shall be connected directly to the metal roof and metal supports with metal conductor holders. The size of the grid should be as per below Schedule. The horizontal air termination conductor should contain an expansion piece at every 20 meters to take care of material expansion due to temperature changes.

If air ventilator, antenna, air conditioner or any other electrical equipment is present above terrace level, the same shall be protected by using vertical air terminal. The vertical air terminal should be placed 30 cm's away from the electrical equipment & has to have suitable supports to hold it. Vertical air terminal must be connected to horizontal air terminal conductor by using suitable connectors. The horizontal air termination should be fixed properly and rigidly so as to withstand wind load.

Material and size of the air termination system shall be according to below schedule.

In case of buildings more than 60 meters height, top 20 % of the building shall be protected with a lateral

air termination system.

Air termination should be connected to the building steel reinforcement if provisions are made in the pillars. All straight Connectors, cross connectors etc should be of stainless steel.

1.4.4 Down Conductor

Down Conductor is required at every 10 meters in the building. More number of down conductors is for current sharing and to reduce lightning electromagnetic effects inside the building.

For buildings with steel columns, no separate down conductor is required. Air termination can be directly connected to the steel columns by special riveting or fastening. Connection of air termination to steel column should be at minimum 0.5 meters below the roof

For buildings with concrete pillars, isolated down conductors can be used. Material Specifications: (Schedule)

- Air termination rod : Copper
- Air termination conductor : Copper
- Down conductor : M/S bar
- All connectors : S/S Cross section:
- Horizontal air termination conductor: Round conductor, 8 mm diameter
- Vertical air termination rod: round conductor 10 mm diameter up to 1 meter height, 16 mm diameter up to 2 meter height and up to 4 meters 40 mm diameter
- Grid size: 10 meter x 10 meter
- Open areas are protected with a grid
-

1.4.5 Zone of Protection

The zone of protection of a lightning conductor defines the space within which Air Terminal provides protection against a direct lightning strike with probability of protection as per LPL.

1.4.6 LPL (Lightning Protection Level)

LPL is a number associated with a set of lightning current parameters relevant to the probability that the associated minimum & maximum values do not exceed the normally occurring lightning. LPL can be determined by Risk analysis as explained in IEC 62305-2 or based on type of building as per application areas. According to the risk assessment, the required LPL level is 2.

Components of External LPS

1. Air terminal (as per rolling sphere or mesh or protective angle method or any combination thereof.)
2. Down conductor
3. Earthing

1.4.7 Air termination system:

No drilling or welding is allowed in the terrace for fixing the air terminal.

Values of Rolling sphere radius, Mesh size and protection angle as per Class of LPL/LPS.

Class of LPL/LPS	Rollingsphere radius(m)	Mesh size (m)	Protection angle
2	30	10*10	Depends on height of the building

Table 2.7 Mesh size and protection angle

Top 20% of the height of the structure shall be protected with a lateral air termination system. This is needed because; the probability of flashes to the side is generally more for structures more than 60 meters in height. Ring has to be formed for every 20 meters height of the building above 60 meters height.

1.4.8 Material and Dimensions

Material of air terminal, down conductor, earth termination etc. shall be as below:

Material	May be destroyed by galvanic coupling with
Copper(Solid)	GI and Aluminium
Hot dip galvanized steel(Solid)	Copper
Stainless steel(Solid)	
Aluminium(Solid)	Copper

Table 2.8 Material of air terminal, down conductor, earth termination

Material	Thickness (a) in mm	Thickness (b) in mm
Galvanized steel	4	0.5
Stainless steel	4	0.5
Copper	5	0.5
Aluminium	7	0.65

Table 2.9 Minimum Thickness of metal in air termination system

Dissimilar metals (For eg copper with Aluminium) must be connected only by using bimetal connectors.

Minimum Thickness of metal in air termination system for LPL /LPS 1 to 4

a- Prevents puncture, hot spot or ignition

b- Allowed only if it is not important to prevent puncture, hotspot or ignition Material configuration and

Min cross sectional area of air terminal and down conductors

Material	Type	Min cross section area	Remarks
Copper	Solid tape	50 sq mm	2mm min thickness
Copper	Solid round	50 sq mm	8mm dia
Aluminum	Solid tape	70 sq mm	3 mm min thickness
Aluminium	Solid round	50 sq mm	8 mm dia
GI	Solid tape	50 sq mm	2.5 mm min thickness
Stainless steel	Solid tape	50 sq mm	2 mm min thickness

Table 2.10 Material configuration and Min cross sectional area of air terminal and down conductors

1.4.9 Air terminal holder

Conductors shall be securely fixed on the terrace by means of air terminal holder which is fixed on the roof by adhesive of good quality taking care of varying weather conditions. Air conductor holder is an insulator & should be of minimum 50 mm height so that even small amount of water logging on terrace is below the level of conductor holder. Air terminal holder shall not be more than 0.5 m apart for a flat conductor & 1m for round conductor of at least 8mm diameter & 1.0 meter apart for vertical run

Recommended distance between air terminal holders.

Arrangement	Recommended distance for SOLID TAPE	Recommended distance for ROUND conductors
Horizontal conductor on horizontal surface.	500 mm	1000 mm
Horizontal conductor on vertical surface	500 mm	1000 mm
Vertical conductor from Ground to 20m height	1000 mm	1000 mm
Vertical conductor above 20m height	500 mm	1000 mm

Table 2.11 Recommended distance between air terminal holders

If antenna, air cooler or any other electrical equipment is present above terrace level, the same have to be protected by using vertical air terminal after calculating the safety or separation distance. The vertical airterminal has to have suitable supports to hold it. Vertical airterminal must be connected to horizontal airterminal by using suitable connectors.

At the crossings of the horizontal airterminals, suitable T or Cross connectors have to be used for secure connection.

1.4.10 Safety or Seperation distance.

It is must to calculate safety or separation distance in order to avoid flash over to the electrical equipment when the lightning current is passing through the vertical air terminal.

Safety/Seperation distance (S) in m = $(k_i * k_c * L)$

/ km Coefficient k_i depends on class of

LPL/LPS. $k_i = 0.08$ for LPL1,

$k_i = 0.06$ for LPL 2,

$k_i = 0.04$ for LPL3 and 4.

Coefficient k_c depends on no of down conductors: k_c

= 0.66 for 2 down conductors $k_c = 0.44$ for 3 or

more down conductors Value of coefficient $k_m =$

1

Value of L is the total distance between the equipment to be protected (for eg. Antenna) to the equipotential bonding bar situated just above the ground

1.4.11 Need for Expansion piece

In order to take care the expansion of the metal in summer and contraction of the metal in winter, expansion piece with suitable connectors have to be used at every 20m distance of horizontal air terminal.

1.4.12 Joints and Bonds

The lightning protective system shall have as few joints. As far as possible air terminal & down conductor have to be straight. Where it is not possible, it should NOT be bent at 90 degree (right angles) & should have a curved path of 45 degree.

1.4.13 Down conductor system

In order to reduce the probability of damage to electronic/electrical equipments, the down conductors shall be arranged in such a way that from the point of strike to earth, several parallel current paths should exist & length of the current path should be minimum. Down conductors can be installed separately or more wisely it can be part of natural components of the building Examples are steel reinforcement in RCC

columns, metal facades, profile rails, metal doors & windows. Down conductors should be installed at each exposed corner of the structure.

Values of distance between down conductors as per Class of LPL/LPS.

Class of LPL/LPS	Typical distance (m)
1	10
2	10
3	15
4	20

Table 2.12 Values of distance between down conductors as per Class of LPL/LPS

1.4.14 Test joints:

At the connection of the earth terminal, a test joint should be fitted on each down conductor, except in the case of natural down conductors combined with foundation earth electrode. The purpose of test joint is to measure the earth resistance value.

1.4.15 Earth Terminations

Earth mat is most preferable. Where earth mat is not possible, ring earthing is the next best method. Ring earthing must be 1 meter away from the building and 0.5m below the ground level. The resistance of earthing system shall not exceed 10 ohm as per IEC 62305. Lower earth resistance is still better.

1.4.16 Type B arrangement.

This type of arrangement comprises either a ring conductor external to the structure to be protected, in contact with the soil for at least 80% of its total length or a foundation earth electrode. Such earth electrodes can also be meshed. For structures with extensive electronic systems or with high risk of fire, type B earthing is most preferable method. Corrosion proofing band has to be used wherever down conductor is connected to earth termination system. Bitumin has to be applied at the point of inter-connection.

In potentially corrosive areas, Stainless steel must always be used.

1.4.17 Test Certificates

A test certificate shall be provided on completion of the installation to certify that Inspection and Testing have been carried out in accordance with the Standards.

The test certificate shall contain the resistance measurement of each earth electrode and earth termination network, of each down conductor and of the building as a whole.

In addition to resistance measurements, the certificate shall contain the following information for each

reading:

- i) The date and time
- ii) The weather conditions
- iii) The type of soil
- iv) The condition of the soil (e.g. wet, dry, average)
- v) Any measures taken to reduce soil resistance
- vi) Details of the reference earth used for testing.

1.5 Emergency Lighting System

1.5.1 General

All emergency luminaries and illuminated Exit signs shall:

- be of the self-contained type exit signs and centralize UPS feed emergency lights.
- comply with all relevant clauses in the “Luminaries” section of this specification.
- comply with BS 5266 Part 1.
- be classified by an approved Authority in accordance with BS 5266. The classification shall be clearly marked on the luminaire label.
- incorporate electronic circuitry for central monitoring of the emergency and exit light installation.

The installation shall:

- connected to an unswitched active from the adjacent normal lighting circuit.
- have sustained type self-contained illuminated exit signs with 230 volt lamp connected to an unswitched active.
- have recessed emergency luminaries, provided with 3 core PVC/PVC flexible cable, fitted with a polarized 3pin plug top.
- have recessed emergency lights incorporated in a normal lighting luminaire provided with a 4 core PVC/PVC flexible cable and polarized 4 pin plug top.

1.5.2 Emergency Luminaries

Emergency Luminaries shall:

- be as specified on the drawings.
- be adequately ventilated.
- contain sealed nickel cadmium cells with the following features:
 - located clear of any heat source.
 - positioned to permit removal and replacement without removing other components, and with the luminaire mounted in position.

- have reverse battery polarity protection
- LED indication of charging mode.
- be provided with a test switch to simulate mains failure.

1.6 Power Outlets And Light Switches

1.6.1 General

Electrical accessories shall be generally in white colour, complying with the relevant BS and products shall be of the same manufacturer as approved by the Consultant.

1.6.2 Socket Outlets

Socket outlets shall be 3 pin, 13A as shown on drawings. All socket outlets shall be switched or non-switched, shuttered type complying with BS 1363 and 546 respectively as specified on drawings.

Weatherproof type shall comply with BS 4343 provided with a push on cap and retaining ring or a screw on cap with rubber gasket.

3 phase 5 pins weather proof type socket outlets shall comply with BS 4343 to IP55 minimum. Each socket outlet shall complete with waterproof plug for further connection to equipment by others.

1.6.3 Fuse Spur Units

Fuse spur units shall comply with BS 1363 and shall be provided with 2A to 13A cartridge fuse link having earthing facilities for connection to the metal work of current appliances being fed.

1.6.4 Appliance Control Switches

Appliance control switches shall be D.P. or T.P. flush pattern, all insulated, white colour with pilot light having the rating of 20A/30A and shall comply with BS 3676. Proper words shall be engraved on to the plate to designate the appliance served such as „air conditioner", BMS equipment" „FS control", security equipment and the like.

1.6.5 Cable Connection Units

The Cable Connection Unit Shall Be Flush Mounted Type With Terminal Blocks Suitable For Fixing Onto The BS 4662 Box And From There Change Into PVC Insulated And Sheathed Cable With Circuit Protective Conductor To The Appliance Served.

1.6.6 Lighting Switches

Light switches shall:

- Comprise a 10A minimum mechanism of rocker operation mounted on an impact resistant plastic grid which can be fixed in position (before final painting of walls) then have its matching snap on cover, fitted (after painting is complete). Switches shall comply with the requirements of BS 3676.
- be a type designed to withstand large inrush currents where used to switch fluorescent and/or discharge luminaires (inrush currents may exceed 15 times full load current.)
- be ganged under a common flush plate where multiple switches are located together.
- be located on the lock side of door frames, except apartment bathrooms.
- be protected type where located in plant areas.
- incorporate a neon indicator where located outside bath rooms.
- be metal clad in lift motor rooms.
- comply with IP55 to BS 5490 where located externally to the building or in damp situations.
- be of selected standard colour range..
- be located clear of building planning modules and grid lines so that future partition walls will not conflict with switch positions.
- be flush mounted within pressed steel wall box where located in masonry and stud partition walls.
- be of the same type and manufacture as general purpose outlets.
- be installed at a mounting height dictated by the Interior Designer or the Architect.
- be fitted with shrouds where located within metal door frames or metal mullions of demountable partitions or where adjacent switches are on different circuits.

Switch panels (Multi gang in excess of 4 switches) shall:

- be flush mounted within a metal wall box.
- be fitted with a stainless steel flush plate 2.5mm in thickness.
- be arranged so that the switches are individually secured within a mounting plate behind the flush plate.
- have the flush plate engraved to indicate the purpose of each switch.
- be suitable for accommodating switches connected to separate circuits and phases.

Light sensitive switches shall:

- comprise a switch board mounted controller with remote sensor head.
- be suitable for switching the controlled lighting systems at an adjustable luminance of 10 - 1000 lux.
- incorporate a time delay to prevent spurious operation during transient lighting conditions.
- be installed in the position shown on the drawings.
- be positioned or shielded so that their operation is not affected by artificial lighting sources.

NOTE: Allow for final adjustment during the hours of darkness.

1.6.7 Position Of Electrical Accessories

The positions of electrical accessories shown on the drawings are approximate, and final positions shall be submitted to the approval of the Consultant.

The Contractor shall be responsible for checking the lighting layouts against structural plans, reflected ceiling plans and other services prior to the installation of conduits, and lighting fixtures so that conflict of light fittings with structural members and services of other trades can be avoided.

The Contractor shall be responsible for measuring rooms and spacing outlets accurately and symmetrically and shall verify the positions of outlets against furniture layouts (if any before commencing installations).

1.6.8 Phase Outlets 3 phase outlets shall:

- be surface mounted where installed in plant areas.
- be flush mounted in polycarbonate enclosure.
- be provided with:
 - Press switch operation
 - 5-pin plug socket
 - Spring loaded flap
 - Screw neck t plug socket
- Have a current rating as shown on the drawings.

1.6.9 Permanently Connected Equipment

Permanently connected equipment will be supplied and set into position and connected to other services by others unless otherwise specified.

Provide isolating switches for each item of equipment, isolating switches shall:

- be of the same current rating as the circuit wiring.
- be mounted adjacent each item of equipment.
- be weather proof where indicated on the drawings on building or in damp situations near water contains or hose down areas.
- be flush mounted in a metal wall box under a plastic flush plate of selected colour.
- be surface mounted where located in plant areas, roof spaces and service ducts.
- be provided for each item of permanently connected kitchen appliances.

Conductors between fixed conduit and equipment shall be enclosed in a length of PVC flexible conduit fitted with brass grip type fittings and of sufficient length to enable the equipment to be withdrawn for servicing.

Make a final connections and leave ready for testing and commissioning by others unless otherwise specified.

Where this specification nominates that final connections will be by others, provide wiring and isolating

switch and leave provision for the extension of circuit wiring to the equipment.

Determine the exact location of the wiring and/or conduit entry for equipment supplied by others before running any conduits or wiring.

Direct connect roller shutter door using controls supplied with the door and adjust as required.

1.7 Site Tests

1.7.1 General

The Contractor shall carry out all necessary checks and tests to prove that the completed installations fully comply with specified requirements.

Upon completion of the electrical installation, or any substantial section thereof, the installation or that section and all of the associated electrical equipment shall be subjected to the tests specified in the relevant National Standards and in the IEE Wiring Regulations, together with such other tests as may be specified in order to prove compliance with the Specification.

Tests not carried out in the presence of the Architect shall not be regarded as valid for the purpose of the Contract, unless the Architect shall have authorized the Contractor to proceed with the testing process in his absence.

Every test certificate shall include, in addition to all other requirements, the date and time of the test, the ambient conditions, a fully detailed description of the test(s) carried out, the results obtained, and any relevant performance curves.

No material, apparatus, equipment, or installation shall be covered or otherwise permanently concealed from view until the Architect has had the opportunity to inspect it, or given written authorization for covering to proceed.

No work shall have a final paint finish until it has been inspected by the Architect or painting has been authorized, unless the final paint finish is necessary to provide the necessary climatic protection.

No apparatus, equipment, plant, or installations will be recognized as complete until all of the specified inspections and tests have been satisfactorily carried out.

The Architect shall have the right to waive, at his sole discretion, the requirements relating to his inspection of materials, apparatus equipment and installations and the witnessing of tests thereon. The exercise by the Architect of this right shall not in any way relieve the Contractor of his obligations to carry out the prescribed tests and to submit test certificates.

Following test should be carried out in all the installations.

Insulation resistance testing - Testing of insulation of cables and bus risers according to the British/IEE Standards to ensure the cables are adequate to prevent electrical fire and in a healthy manner. Require power isolation.

Loop resistance test - Testing of earth loop impedance to ensure the connectivity of earthing conductors, to analyze earth fault trip settings, etc. Intermittent Power cut will be experienced, verification of Earth Fault Protection coordination.

RCCB Testing - To check necessary RCCBs according to IEE/IEC standards. During the test tripping will happen.

- Continuity test on bus risers
- Continuity test on Earthing and Bonding

Following analysis should be carried out in all the installations.

Visual Inspection - Visually inspect the distribution paths, switch gear, selected lighting fittings, earthing network, Surge arrestors etc. Do not require power isolation. (Verification of the as built distribution system. and updates if any and establishing sectional isolation points if necessary)

Cable Breaker Coordination analysis - Analyze the loading capacity of cables for installed circuit breakers according to British/IEE Standards. Do not require power isolation.

Fault level calculation - From Main Distribution board to each floor Distribution

Board Earth Fault Setting calculation - From Main Distribution board to each floor Distribution Board Further to above Thermo graphic survey of the electrical system From Main Distribution board to each floor Distribution Board to be required to done.

1.7.2 Cable Testing

As soon as is practicable after the completion of installation and jointing of the cables specified herein, or of any usable group of such cables, the Contractor shall carry out the tests described below, together with such other tests and measurements to prove compliance with this Specification and with the requirements of the IEE Wiring Regulations.

An insulation resistance test, carried out with a 'Megger' insulation tester or other similar type of testing instrument, to measure the insulation resistance between each conductor and the remaining conductors and between each conductor and the metallic sheath, if any, and armoring. The test voltage to be applied shall be as follows:

Low voltage cables - 500 volts

High voltage cables - not less than 1000 volts

The above tests shall be carried out both before and after any voltage tests and the insulation resistance shall not be less than the figures in BS 6346, Table 6, for all cables up to 3.3kV. The Contractor shall submit insulation resistance figures for cables above 3.3kV.

A voltage withstand test of 15 minutes duration shall be applied in accordance with the relevant British Standard, at the test voltage indicated in:

BS 5467, Table 7, of for cables with thermosetting insulation, BS 6346, Table 5, for PVC insulated cables, or BS 6480, Table 6, for paper insulated cables.

The Contractor shall submit proposals on the appropriate test voltage in respect of other types of cable. Mineral insulated cables shall be subjected, on completion of installation and jointing, to a voltage test in

accordance with BS 6207 Clause 8, for copper sheathed cables. The test voltage shall have the value tabulated in the appropriate Appendix, and shall be applied for 30 seconds.

An earth continuity test shall be carried out to verify that the cable armouring and metal sheath, if any, have been properly bonded to earth.

Phase-rotation and phase-correspondence shall be tested to prove that the cables have been correctly connected.

Where a new cable has been jointed to an existing cable, the voltage withstand test specified above maybe carried out at a reduced voltage if the existing cable has been in service for more than five years. In such a case the test voltage shall be determined by applying a factor K to the value given in the appropriate British Standard as referred to above, and the value of K shall be as given in the following table:

Age of existing cable	in years K
0 - 5	1.0
5 - 10	0.9
10 - 15	0.8
15 - 20	0.7
20 - 25	0.6
25 - 30	0.5

Table 2.13 Value of K

1.7.3 Low Voltage Switchboard Tests

Low voltage switchboards shall be thoroughly checked for correct functioning in every respect and shall be subjected to the following tests:

With all control circuits disconnected but with all isolators closed and power fuses fitted, the panels shall be subjected to a voltage test across the following points:

- Phase to phase
- Phase to neutral
- Phase to earth
- Neutral to earth

The voltage levels and test direction shall be in accordance with the relevant National Standard for the equipment provided.

This shall be followed by an insulation resistance test with an approved type of 500 V test instrument. With all electronic components and time switches removed or isolated and with all main isolators closed and power fuses fitted, an insulation resistance of not less than 20 Mega ohms shall be obtained between each of the following points:

- Phase to phase
- Phase to neutral
- Phase to earth
- Neutral to earth

1.7.4 System and Equipment Earthing

The Contractor shall inspect and carry out tests on all the system and equipment earthing provisions in accordance with the requirements of the IEE Wiring Regulations.

The method of test and the selection of suitable test instruments shall conform to the guidelines given in the IEE Wiring Regulations.

These tests shall be carried out on all system and equipment earthing supplied, installed and connected under this Contract.

Where an existing installation has been effectively extended in relation to the system and equipment earthing provisions supplied under this Contract, the existing system and equipment earthing shall be inspected and tested for compliance with the IEE Wiring Regulations.

The Contractor shall inspect and re-test the system and equipment earthing provided under this Contract thirty days prior to the end of the Defects Liability Period. The Contractor shall give the Architect seven days' notice of his intent to carry out these tests.

1.8 Sundries

1.8.1 Painting

Items of equipment provided as part of this sub-contract, e.g. switch boards, light fittings, control panels etc., shall be painted off site in accordance with the requirements specified herein.

Where damage occurs to the paint work of such equipment, the damaged item shall be returned to the respective paint shop where it shall be refinished with primer and final coats to restore the surface to its specified conditions of colour, finish and quality.

All switch boards, control panels and the like shall be cleaned down and polished with automotive polish prior to practical completion.

Exposed conduits, wiring ducts, cable trays, brackets, frames, covers etc., shall be painted with at least two (2) coats of best quality of oil paint of selected colour.

Wherever possible one (1) coat shall be applied prior to installation in position. At least one (1) coat shall be applied after erection

1.8.2 Fixings

Fix in positional equipment and materials supplied as part of this unless otherwise specified. All fixings shall:

- Be approved by the Consultant.
- Comprise metal thread screws or bolts into expanding type masonry anchors for fixings to concrete or masonry.
- Comprise tapered wood screws for fixings to timber framing.
- Be electro galvanized finish for all bolts, nuts, washers and screws/
- Be brass where installed externally to the building or in damp situations.
- Be provided with spring washers where installed on equipment which is subject to vibration.

- Be of no less corrosion resistance than the parts being fastened and shall be the same or more noble material so that they will not be preferentially corroded.

Nuts and bolts shall:

- have heads which are hexagonal in shape
 - be provided with flat washers
 - have metric threads in accordance with ISO 68
 - be tightened to show one full thread beyond the nut
- The following fixings are NOT acceptable:
- fixings made by the use of explosive powered tools
 - fixings made in the mortar joint in block or brick work.
 - fixings into plaster board, asbestos cement, ceiling tiles or similar friable material. In these instances the sub contractor shall provide fixed battens to secure the fixing.
 - Self-tapping screws into sheet metal
 - Nails

1.8.3 Building Penetration

The locations of all penetrations through the building structure shall be submitted for approval prior to their installation.

All penetrations shall:

- Be sized and located by the contractor.
- Be sealed with approved fireproof packing after installation wiring through fire rated barriers so that the integrity of the fire rating is maintained.
- Have sleeves, block outs etc., provided by the contractor where necessary.
- Be drilled or cut out by the contractor where they have not been provided during construction or the wall, floor etc.

1.9 Brand Specification

Items	Acceptable Brand Names
ACB	ABB, Siemens, Schneider, Merlin Gerin, Terasaki OR EQUIVALENT
MCB/MCCB/ATS	ABB, Merlin Gerin, Mitshubishi, Terasaki, Schneider, Soccomec, Siemens OR EQUIVALENT
Surge Protective Devices	OBO Bettermann, Eaton, Novaris OR EQUIVALENT
Power Factor correction capacitor bank	ABB, Eaton, DLab, Schneider OR EQUIVALENT
Uninterrupted power supplies	APC, Emerson OR EQUIVALENT
Numerical EF & OC relays	ABB, Areva, Merlin Gerin, Siemens, DLab OR EQUIVALENT
ELR/EFR	Hager, DLab, Lovato, Mikro OR EQUIVALENT
RCCB	ABB, Hager, Merlin Gerin, Siemens, Schneider OR EQUIVALENT
Times Switch	Hager, MK, Merlin Gerin, Siemens, Schneider, Omron, OR EQUIVALENT

Contactors	Hager, Telemechnique, OR EQUIVALENT
PVC,PVC/PVC,PVC/SWA/PVC	ACL, Kelani, havells OR EQUIVALENT
XLPE/PVC	ACL, Kelani, Havells OR EQUIVALENT
Cable Trays, trunking, Ladders	OBO Bettermann, EAE,ICMS, Metakson, Ardic OR EQUIVALENT
PVC Conduits	Aurora, Rexton, Polycrome, Lesso, IDuct OR EQUIVALENT
GI Conduits	Aurora, Rexton, Polycrome, Lesso, IDuct, Rexway OR EQUIVALENT
Light Fittings	PHILLIPS, YLI, DST, SJLITE, CDN, NVC, OR EQUIVALENT
Air Craft Warning Lights	DELTA, ORGA OR EQUIVALENT
Switch, Socket outlets	Legrand, Schneider OR EQUIVALENT
Panel Enclosure	Elsteel, KIK, PUBUDU OR EQUIVALENT

Note:

- All brands mentioned above are preferred in terms of local supports, after sales services and spare parts only

5. TECHNICAL SPECIFICATIONS OF EXTRA LOW VOLTAGE SYSTEM

ABBREVIATION

- ACS - Access Control System
- BGM – Background Music
- BMS - Building Management System
- CCTV - Closed-Circuit Television
- ELV – Extra Low Voltage System
- EVE - Emergency Voice Alarm
- IP - Internet Protocol
- LAN - Local Area Network
- O&M - Operation and Maintenance
- OEM - Original Equipment Manufacturer
- PA - Public Address
- PoE - Power over Ethernet
- SLD - Single Line Diagram
- UPS - Uninterruptible Power Supply
- VMS - Video Management System
- CRMS - Cold Room Management System

5. TECHNICAL SPECIFICATION FOR ELV SYSTEM

5.1 General Description and Extent of Work

The scope of work under this specification covers manufacture/ procurement, assembly, factory inspection & testing, transportation of materials to site, storing, unloading and transportation from store to site and handling at site, erection, testing, commissioning and performance guarantee tests of equipment and accessories of all ELV Services of the Project.

The scope of work by the Contractor shall include but shall not be limited to the following:

To manufacture and supply the complete of all ELV Services and associated equipment specified under this technical specification.

To supply at site required materials in order to execute incidental works at site associated with of all ELV Services Systems specified under this technical specification and consumables as required.

Supply of any spares as may be required during erection, start up and initial operation of all the units/ systems till successful completion of commissioning. The price for such spares shall be deemed to be included in the contract price for the offered systems.

Supply of recommended spares for two years' normal operation of the total ELV Services with item wise price breakup.

Supply of special tools required for maintenance of all ELV Services. Preparation and submission of a necessary load calculations, general arrangement drawings, design drawings, fabrication & erection drawings, as built drawings, drawings of fast wearing parts (if any) etc. Approval shall be taken on the load calculation, system layout drawings and equipment general arrangement drawings before start of erection.

Erection of all the equipment and complete of total ELV Services as per approved drawing and instructions given by customer / Owner/ Consultant.

Minor civil work like breaking of wall /floor /roof to make duct / pipe / cable passage and adjustment to civil foundations as required for erection and finishing and making good of the same after erection work including painting thereof. Fixing of anchor fastener on wall and ceiling for support is also to be included.

Any other item /nature of work which is specifically not appearing in the technical specification but directly associated with the efficient working / completion of the system covered in the specifications.

Submission of operation, maintenance and service manuals.

Inspection and testing by Owner/Client's representative at works and at site.

Performance testing of various equipment associated with all ELV Services at manufacturer's works and performance testing of all ELV Services at site.

All necessary skilled/unskilled personnel, cranes, hoist, tools and tackles, instrument and accessories shall be arranged free of cost by the Contractor for transport assembly, erection, performance testing and commissioning of the systems.

Bidder must note that completeness of system for safe, smooth, trouble free operation and compliance with Local/International regulation is the sole responsibility of the Contractor i.e., the successful Bidder. With this objective in mind, the Bidder should include all the items essential for the efficient operation of the systems and other items which are required to complete the erection and fool proof commissioning of systems in respects. Whether the items are mentioned in the specification or not, all such items are treated/considered to be included in the specifications.

When any services passing the fire rated compartments/wall or any barriers all sleeves or opening to be properly sealed with fire rated sealants.

The Contractor i.e., the successful Tenderer shall be solely responsible to provide the above items at site without any extra cost implication to Client.

5.2 General Instructions to Bidder

The technical specification inclusive of instructions/special instructions to bidder shall be read along-with General Conditions of Contract and instructions to Bidder, for the supply and erection of plant, machinery, and equipment.

The equipment shall be designed, manufactured and tested in accordance with the relevant standards prescribed by the Sri Lankan Standard Institution wherever possible. In cases where suitable Sri Lankan Standards are not available, the equipment shall conform Good Manufacturing Practice followed in the industry.

The equipment offered shall be suitable for continuous, smooth, efficient and trouble-free services in the climate prevailing at the site, continuous duty condition.

The Contractor shall not off-load the contract or part thereof to any sub-contractor without written permission of the Employer. In the event of subletting the contract or any part thereof is permitted by the Employer, the fact that such permission has been accorded shall not establish any contractual relationship between the approved sub-contractor and the Employer and nor shall release/ free the Contractor from the obligations under the contract. Facilities shall be provided by the Contractor to enable the Employer's authorized inspector to inspect the equipment and their auxiliaries at all stages of manufacture to satisfy themselves as to the use of proper material and workmanship and apart from this the equipment shall be tested or suitable test facility shall be provided by the Contractor to enable checking of operational parameters.

At the time of inspection, the Contractor shall furnish internal routine inspection certificate, material certificates, approved drawings, etc. to the inspector. Inspection shall be regarded as check-only and shall in no way relieve the Contractor of his responsibilities to provide systems & equipment functions as designed.

The Contractor shall take full responsibilities for the guaranteed operation and achieving rated out-put and performance of the systems offered as per relevant clause of specifications.

The bidder shall information required for smooth functioning of the systems including operation, day to day maintenance, preventive maintenance, capital repairs, schedules and programs and any other information required by the Employer for trouble free operation of the systems along-with the supplies.

The scope of work for the bidder shall not include provision of room and foundation for the systems. However, the necessary load data shall be furnished along with the offer by the Tenderer so as to complete the civil work at site as per the schedule of completion of respective buildings.

The Contractor shall adhere to the schedule for supply, installation, testing and commissioning etc.

The Contractor shall ensure that each equipment is provided with name plate engraved in English language with the details like Supplier's address, operation and design parameters, weight, and precautions etc.

The Contractor shall ensure that the systems are designed considering the fire safety norms and adequate fire safety measures.

This section applies to all sections of ELV Services except as specified otherwise in the individual sections.

Complete ELV Services shall be furnished and installed as shown on drawings and specified under this section. Coordinate timing of installation with work of other trades.

5.3 Standard Codes and Regulations

All works performed, and equipment and materials supplied and installed under the contract shall comply in every respect with the rules and regulations of,

- ✓ Relevant ICTAD Specification
- ✓ Local Fire Regulation
- ✓ Current Edition of The Relevant British Standard Codes of Practice

The relevant British Standard Specifications (BS), TIA/EIA, IEC or approved equivalent, not limited to following. All other authorities having jurisdiction over the installation.

- i. BS 7671:2018+A1:2020 - Requirements for Electrical Installations (IET Wiring Regulations).
- ii. BS EN 50173-1:2020 - Information technology - Generic cabling systems.
- iii. BS EN 50174-1:2018 - Information technology - Cabling installation.
- iv. BS EN 62305-3:2011 - Protection against lightning - Part 3: Physical damage to structures and life hazard.

- v. BS EN 62305-4:2013 - Protection against lightning - Part 4: Electrical and electronic systems within structures.
- vi. BS 6259-1:2010 - Code of practice for the design, installation, commissioning, and maintenance of sound systems for emergency purposes - Part 1: Specification for design, installation, and commissioning.
- vii. BS EN 60849:1998 - Sound systems for emergency purposes Description: This standard specifies the requirements for sound systems intended for emergency purposes, such as emergency evacuation and public address systems. It covers aspects like system design, installation, and testing.
- viii. BS 6259-2:2015 - Code of practice for the design, installation, and maintenance of sound systems for non-emergency purposes - Part 2: Specification for design, installation, and maintenance.
- ix. BS EN 62368-1:2014 - Audio/video, information, and communication technology equipment - Part 1: Safety requirements.
- x. BS EN 50133-1:2012 - Alarm systems - CCTV surveillance systems for use in security applications.
- xi. BS EN 60839-11-1:2013 - Alarm systems.
- xii. BS 7858:2019 - Security screening of individuals employed in a security environment - Code of practice.
- xiii. BS EN 16763:2017 - Services for security systems and fire systems - Service requirements, competency, and certification of services for electronic security systems
- xiv. BS EN 301 489-17:2013 - Electromagnetic compatibility and Radio spectrum Matters (ERM) - Electromagnetic Compatibility (EMC) standard for radio equipment and services.

5.4 Standards Compliance

Materials and equipment specified to conform to referenced standards and codes require proof of such conformance. Labels or listings indicating such compliance are acceptance evidence. In lieu of label or listings provide a certificate form an independent testing organization acceptance to the Engineer.

For materials and equipment whose compliance with organization standards or specifications is not regulated by listing or label, provide manufacturer's certificate of compliance.

Certificates of compliance shall identify manufacturer, product, referenced standards and manufacturer's certification that the product conforms to all requirements of the project specification and listed reference standards.

5.5 Schedule of Technical Data and Manufacturer's Technical Pamphlets.

Manufacturer's Technical Pamphlets giving full technical data for all equipment to be offered by the Tenderer shall be submitted together with the Tender. The Schedule of Technical Data

shall be dully filled. Equipment to be offered by the Tenderer shall bear both Manufacturer's Name and List Number.

Phrases like "As Specified", or "Equivalent", "Submit at a later date", "Sri Lankan Made" will not be acceptable in the Schedule of Technical Data.

Where there is discrepancy between the Schedule of Technical Data attached to the Tender Documents and the Specifications mentioned on Manufacturer's Technical Pamphlets, the Schedule of Technical Data should prevail. And bidder shall clearly indicate any kind of deviation between the bid document and his submission clearly in a separate document.

Tenderers must fill-in their tender strictly in compliance with the Engineer's base specification in regard to nominated makes of equipment/material. Any error in specifications must be clarified with the Engineer before submission of tenders, who will issue addenda thereof.

The original form of Schedule of Technical Data must be filled in accordance with the Engineer's base specification or amendments thereof, failing which the client reserves the right to ask the Tenderer to comply with Engineer's base specification at tendered price or else the client reserves the right to forfeit the Tenderer's Tender Deposit and Tender Bond.

Bidders are fully encouraged, however, to propose alternative specifications which can achieve genuine economy in cost or technical benefits, but these same alternatives and their cost implication thereof must be filled separately in a separate covering letter with a Schedule of Technical Data and not the original Tender Schedule. However, this proposal should be in full compliance with the given technical requirements.

5.6 Equipment and Material Approvals and Samples Review

Within 14 days after the award of any contract, the Contractor shall submit for approval a list of manufacturers of equipment and material proposed for the work. The Contractor's intent to use the exact makes stated in their tender does not relieve them of the responsibility of submitting such a list. All equipment and materials shall be new and unused.

Wherever the words "equal", "approved equal", "as approved" appear in the specification, this shall mean approved in writing by the Consulting Engineer.

Each item of equipment shall be a standard catalogue product of an established, reputable, approved manufacturer. All similar equipment shall be of the same manufacturer, type, class and finish, unless otherwise specified.

Where manufacturer's catalogue numbers or types are specified or shown on the drawings, they are generally intended to be used as a guide and are not intended to take precedence over the basic duty and performance specified or shown. In all cases, verify the duty with the particular characteristics of the equipment offered for approval.

Where no alternative materials are noted in the specification or on the drawings and where the words "equal", "approved equal", or "as approved" etc., do not appear, the exact make specified must be supplied and installed.

Orders must be placed within thirty (30) days of tender award. Major equipment orders shall be forwarded to the Consulting Engineer for approval before purchase.

Samples: Where approval of products is specified submit samples or other evidence of suitability for review by the Engineer. Resubmit samples as necessary until an acceptable standard is reached. Do not confirm orders, commence manufacture or use products until approval of samples have been obtained.

Materials Application: Materials submitted for review shall be forwarded using a standard application form format to be agreed with the Engineer. Enter the date by which review.

Information is required. Allow a reasonable time for review and indicate urgency where necessary.

All necessary skilled/unskilled personnel, tools and tackles, instrument and accessories shall be arranged free of cost by the Contractor for assembly, erection, performance testing and commissioning of the systems.

Bidder must note that completeness of System for safe, smooth, trouble free operation and compliance with Local/International regulation is the sole responsibility of the Contractor i.e., the successful Tenderer. With this objective in mind, the Tenderer should include all the items essential for the efficient operation of the systems and other items which are required to complete the erection and foolproof commissioning of systems in respects. Whether the items are mentioned in the specification or not, all such items are treated/ considered to be included in the specifications.

The Contractor i.e., the successful Tenderer shall be solely responsible to provide the above items at site without any extra cost implication to Client.

Review Categories: Shop drawings, Materials Samples, Mock-ups and similar submittals will be reviewed and classified in one of the following categories:

- | | |
|---|----------------------------|
| A. approved without comment | - no resubmission required |
| B. approved when comments are fully complied with | - no resubmission required |
| C. approved with comment | - to be resubmitted |
| D. disapproved | - to be resubmitted |

Mock-ups: Provide mock-ups as required by the specifications. Mock-ups will be subject to review and are to be adjusted until an acceptable standard is achieved. These are then to be protected and remain in place to form a minimum standard for comparison of subsequent work. Mock-ups may form part of the final construction as may be agreed with and directed by the Engineer.

5.7 Equipment and Material Deviations

The dimensions and ratings of equipment specified herein or indicated on the drawings are intended to establish the outlines and characteristics of equipment furnished by the particular manufacturer or manufacturers specified.

Where the Contractor intends to use an item of equipment or material other than that specified or shown on the drawings or in the Schedules, the Consulting Engineer's approval therefore must be obtained in writing.

Should any bidder include in his offer equipment or material other than that shown in the drawings and schedules, such equipment or material must conform fully to the requirements for these items as shown in the drawings and schedules. Acceptance of any tender which includes equipment and material which differ in any respect to that equipment and material shown on the drawings and Schedules, in no way relieves the Contractor from complying with the specification, drawing and Schedules.

Where such approved equipment deviations require a different quantity and arrangement of piping, wiring conduit and equipment from that specified or shown on the drawings, the Contractor shall furnish and install any such additional piping, structural supports, electrical materials, insulation, and equipment required by the system without additional charge.

5.8 Submittal

The following items shall be requiring to be submitted to the Engineer for review and Complete system design layout and description of components.

- a. Schematic diagrams
- b. Shop drawings
- c. Technical data sheets
- d. Warranty letters from manufactures
- e. Maintenance schedules
- f. Test certificates for the system
- g. Standard Compliance Certificate

5.9 Intent of Drawings and Specifications

It is the intent of the Specification and drawings relevant to this Contract to call for finished work, tested and commissioned. Any apparatus, appliance or material not shown on the drawings but which is mentioned in the specification or vice versa, or any incidental appliance or materials, services which may be necessary to make the work complete and perfect in all respect and ready for operation, even if not particularly specified, shall be furnished, delivered and installed without any additional costs.

The plan as drawn are based upon architectural plan and detail and show conditions as accurately as it is possible to indicate them in scale. The plans are diagrammatical and do not necessarily show all accessories, fixings etc., necessary to fit the building conditions.

The locations of outlets, apparatus and equipment shown on the plans are approximate. The Contractor shall be responsible for the proper location of all devices to make them fit with architectural details and instructions from Engineer's representative at the site.

5.10 Shop Drawings, Working Drawings and Details

After receiving approval of the equipment manufacturers submit for approval, without delay, and prior to purchase or fabrication, not less than six (6) copies of detailed, dimensioned shop drawings or cuts of equipment showing general construction, size, arrangement, levels and setting out details, fixing details, operating clearances, related builders work information and requirements, performance characteristics and capacity of all specialties, together with sufficient engineering data to indicate substantial compliance with the respective specifications.

Positions of all control equipment, including related components, shall be shown on shop drawings.

Each item shall be identified by name and numbers as shown on the equipment schedules, control drawings and specification.

Working drawings of the complete installation, prepared by the Contractor shall be submitted in triplicate for examination and comment. Each drawing will be examined and approved or corrected or disapproved by the M&E Engineers, and returned to the Contractor, who shall then print the necessary copies of each approved submission for distribution. Disapproved drawings shall be corrected and resubmitted.

Drawings shall be of 1:100 scale minimum except in critical areas where 1:50 or larger scale as appropriate shall be used.

Inspection of shop and working drawings shall not be considered as a guarantee of measurements of building conditions. Where drawings are inspected, such inspection does not in any way relieve the Contractor from his responsibility nor from the necessity of furnishing material or performing work required by the contract drawings and specification, which shall, in the event of a dispute, take precedence over shop drawings.

The submission of shop and working drawings (in either the original submissions or resubmitted with corrections) constitutes evidence that the Contractor concerned has checked all information thereon and that they accept and are willing to perform the work as shown in a workmanlike manner and in accordance with the best standard practice. It also constitutes evidence that all control diagrams, all electrical diagrams and all submissions of any kind are fully understood by the Contractor and that in their opinion the equipment will perform as specified. No claim for extra shall be based on work shown on shop and working drawings, unless such claim is so noted on the Contractor's transmittal letter accompanying the drawings.

A responsible person of the Contractor's staff shall sign all drawings submitted, including those by suppliers.

Submit for approval within fourteen (14) days of the contract being awarded two (2) copies of a schedule of shop drawings showing the following.

- ✓ Drawing Number
- ✓ Title
- ✓ Planned Date of Submission

Dates of submission and approval shall be coordinated with the Building Programme. Shop drawings shall be submitted for inspection to the M&E Engineer, minimum of 14 days prior to the required return date.

Failure of the Contractor to include all shop drawings on this schedule shall not relieve them of their responsibility to submit all required shop drawings on time to permit correct processing as specified herein.

The Contractor is responsible for ensuring that shop drawings are kept up to date incorporating modifications arising from instructions. Reissue updated shop drawings as may be required by the Engineer.

5.11 Record Drawings, As-Built Drawings, and Operation and Maintenance Manuals

Record Drawings: During the course of the works the Contractor shall maintain fully detailed records of all changes from the tender drawings to facilitate easy and accurate preparation of the record drawings and to ensure that these drawings are in all respects a true record of the installation.

Content: The drawings shall show the complete installation, including the size and runs of all ducts and pipework. The scales shall be such that details, particularly of the plant, can be clearly shown. The drawings shall show the names of the manufacturer, model and type numbers and all the details of duty and rating of all items of the plant, including thermostatic control equipment. The drawings shall include the geographical location and identification number of each circuit control valve in accordance with the labelling and circuit control diagram.

Diagrams: A print of each of the composite record circuit and layout diagrams shall be fixed securely to the inside of the hinged front of the main electrical control panels as appropriate, or in such other alternative positions as may be agreed by the Engineer and shall be protected by non-flammable transparent material. Where inadequate space exists, the prints shall be suitably reduced in size.

Operations and Maintenance Manuals: The Contractor shall also provide Operations and Maintenance Manuals, wiring diagrams, valve charts, test certificates and the like as required by these Specification. Three copies of the Operations and Maintenance Manual shall be handed to the Engineer before Practical Completion. 2 copies of the O & M manual In CD format shall also be submitted. The files in the CD shall be in PDF or text format.

Manual Format: The format of the manual shall be A4 size white paper for typed pages with neatly typewritten text, and manufacturer's printed data. Drawings shall be sized that they may be folded to the size of the text pages. Each volume title of the manual shall be identified with the typed or printed title, 'Operations and Maintenance Manual', the title of the project and the identity of the general subject matter covered in the manual. The text and drawings shall be placed in commercial three ring binders with durable and cleanable plastic covers. When multiple binders are used, the instructions shall be correlated into related consistent groupings. Each manual volume shall contain a neatly typewritten table of contents arranged in a

systematic order giving the Contractor, name of responsible principal, address and telephone number, a list of the name, address and telephone number of the contractor or installer. Only the manufacturers printed data, which is pertinent, is to be included.

Each sheet of manufacturer's instructions shall be annotated to identify clearly the specific item or part installed and the instructions applicable to the installation. All inapplicable information shall be deleted.

Supplementary Data: Data shall be supplemented with drawings as necessary to illustrate clearly component parts of equipment and systems, control diagrams, flow diagrams and test procedures covered in the manual. Written text shall be organized into a consistent format under separate headings for different procedures and in a manner to provide a logical sequence of instructions for each procedure.

Organization: Organize the Operations and Maintenance Manual as follows:

Volume 1

- ✓ Part 1: Introduction
- ✓ Part 2: System Description
- ✓ Part 3: Operating Procedures
- ✓ Part 4: Fault Finding
- ✓ Part 5: Preventive Maintenance
- ✓ Part 6: Appendices:
 - ✓ List of Drawings
 - ✓ Equipment Data and Spare Parts
 - ✓ List of Manufacturers and Agents
- ✓ Publications (catalogues, selection tables, etc.)

5.12 Operations and Maintenance Instructions

The Contractor shall demonstrate and explain the plant and the method of starting, running and stopping to the Architect or Employer's representatives. During the defects liability period the Contractor shall allow for providing trained operators to attend, operate and maintain the plant as directed by the Architect. Demonstrate the purpose, function and operation of the installations including all items and procedures listed in the Operations and Maintenance Manual. Over this period the operators shall also instruct the Employer's staff in the correct maintenance and operation of all plant and equipment. The Contractor shall also assist the Employer in formulating any maintenance contracts with suppliers of equipment and the Contractors that the Client may require. The Contractor shall provide five sets of operations and maintenance instructions (hard copies) and two (2) soft copies of the O & M manual in CD format. The files in the CD shall be in PDF or text format.

5.13 Record Drawings (i.e., updated shop drawings)

Unless otherwise indicated, the Contractor shall provide before the Practical Completion the following drawings:

- ✓ Four sets of installation working drawings.
- ✓ Four sets of detailed plant room drawings.
- ✓ Four sets of purpose made diagrams detailing separately all the composite electrical circuit and wiring layouts.
- ✓ Four sets of builder's work drawings.
- ✓ one set of reproducible as fitted drawings, process negatives and computer discs for use with AutoCAD upon completion of the work.

5.14 Completion

Adjust copies of all Shop Drawings to record final installation. Submit five (5) complete finalized sets before Practical Completion. Supply copies of all associated supplementary manufacturers or other data necessary to form a full and complete record of work done.

5.15 Additional Data

Provide details of any errors, variations, omissions or additional information which is not instructed, directed or indicated on the contract drawings, but which becomes apparent from construction. Information is to enable record drawings to form an accurate record of final construction. Details to be submitted as the work progresses and shall be complete by the Practical Completion.

5.16 Manufacturers Input

Retain copies of maintenance instructions and documents delivered with components and equipment or obtain from manufacturer as necessary and submit before Practical Completion.

5.17 Spare Parts

On completion of the testing and commissioning of the ELV Services installation, spare parts required by the specification shall be supplied and submitted.

5.18 Lists

At time of handover provide a comprehensive list of all manufacturers, suppliers and local agents for all items used in the construction of the works. Include the following data:

- ✓ Product/ service
- ✓ Specification/ instruction reference
- ✓ Company name
- ✓ Address
- ✓ Telephone and fax numbers

- ✓ Contact name, title and position

Upon completion of the job, the Contractor shall furnish to the Employer, their original tracings or reproducible transparencies of all electrical works, shop drawings and equipment layouts. They shall note on the as-built drawings, furnished by them, the corresponding number of the applicable shop drawings. Where shop drawings are not available, the Contractor shall neatly indicate the changes on the as-built drawings.

5.19 Quality Assurance

The Contractor shall operate and maintain a Quality Assurance programme to ensure that the Contract is completed in accordance with the approved programme and to the standard specified.

Work procedures shall be documented and shall be available to satisfy the Architect of the effectiveness of this program in the following areas at contract execution.

- ✓ Procurement, manufacture and packaging
- ✓ Construction and erection
- ✓ Manufacturer's Instructions

Where installation procedures are specified to be in accordance with the manufacturer's instructions, provide published copies prior to installation. Installation of materials and equipment will not be allowed until the instructions are received.

Failure to furnish manufacturer's instruction can be cause for rejection of the materials.

5.20 Progress Photographs

In addition to progress photographs required for monthly progress reports keep a portfolio of progress photographs on site which act as a record of the progress of key areas of the works and key events as directed by the Engineer.

5.21 Completion and protection:

Protection

Protect building finishes, fixtures and fittings and prevent damage to existing property. Move, cover and protect as necessary to enable the works to be executed and replace in original positions upon completion.

Special Protection

Wherever work is of an especially vulnerable nature or is exposed to abnormal risks provide special protection to ensure that damage does not occur. Replace or repair any damaged components or finishes.

Waste Material

Remove rubbish, waste, debris and surplus material regularly and keep the site orderly and clean. Remove all rubbish, dirt and residues from voids and cavities in the construction before closing in. Dispose of waste material at an approved location and obtain all necessary permits.

Cleaning and touch up

Remove all temporary markings, coverings and protective wrappings unless otherwise instructed. Clean finished work thoroughly, remove all surplus material. Cleaning materials and methods shall be as recommended by product manufacturers. Touch up minor faults in finishes or repaint badly marked areas back to suitable breaks or junctions.

5.22 Lubrication

Adjust, ease and lubricate moving parts of new work as necessary to ensure easy and efficient operation.

5.23 Defects

Defects are to be reported to the Engineer without delay. Obtain directions before proceeding with work which may cover up or otherwise hinder access to defective construction or be rendered abortive by the carrying out of remedial work.

5.24 Practical Completion

Preparation

During the weeks leading up to Practical Completion, the Architect and engineering Consultants will monitor commissioning tests with the contractor and his sub-contractors. A programme of such tests is to be agreed well in advance to ensure a systematic and progressive approach towards building handover. The Contractor shall pay particular attention to the production of Record Drawings and Maintenance Manuals. Their production will be progressively reviewed in order that they are finished by the Date of Completion.

Preparatory Inspection

Two weeks prior to the anticipated date of Practical Completion a formal inspection of the works will be undertaken jointly by the Architect, engineering Consultants and the Contractor. The Employer will be invited to send representatives to this inspection. Lists of defective and incomplete work are to be prepared together with the Architect and engineering Consultants, together with a check list of outstanding documentation related to the documents required to be handed over by the Contractor at Practical Completion. The Architect will consolidate these lists and forward to the Contractor for action. Action related to the lists will be monitored in the remaining period to Practical Completion.

Handover

As soon as the Architect is of the opinion that Practical Completion has been achieved, he will arrange a formal Handover Inspection with the Employer. Any remaining defects or

pending documentation will be listed for immediate action by the Contractor within seven days unless otherwise instructed by the Architect.

Defects Liability Period

Defects will be reviewed at joint site inspections with Consultants and the Contractor. The Architect will coordinate input from all disciplines and prepare a Defects List that will be updated and reissued following inspections throughout the Defects Liability Period. Permission for access to accommodation for making good defects is to be obtained strictly in accordance with Employer, the Contractor and user requirements. Defects are to be made good promptly and expeditiously.

Training

The Contractor shall allow in his Contract price the service of a competent personnel to instruct the Owner's maintenance staff in the operation and maintenance of the installation and equipment during the initial operation of the system, subsequent to the issue of the Certificate of Practical Completion or handing over of the Works to the Owner whichever is earlier.

Maintenance and Guarantee

All equipment supplied and installed shall be in good working order and shall be guaranteed for a period of 12 months from the date of handing over the completed installation to the Owner. This guarantee shall include the equipment manufacturer's standard warranties and the Contractor's own guarantee on all other materials supplied and installed by them.

The Contractor shall make good any defects to the components of the equipment that may arise from fair wear and tear during the guarantee period.

Any component of the installation which fail to achieve the guaranteed performance to be replaced by the Contractor without delay and without any charge.

During the above-mentioned guarantee period the Contractor shall provide free regular maintenance to all ELV Services and ensure that all systems are maintained in first class running order. The maintenance shall include systematic examination, cleaning, adjustments, testing.

During this guarantee period the Contractor shall also provide emergency breakdown maintenance.

The Contractor shall maintain a detail record of all services, maintenance and repair work carried out. Such record shall be prepared in duplicate and should be in a form of Maintenance/ Repair sheet, with one copy to be retained by the Owner upon the execution of such services. Record of such service, maintenance or repair shall also be entered in the maintenance log book provided at the site.

5.25 Day works

Submittals

Day work sheets shall be submitted regularly not later than the end of the week following that in which Day works were done. The Contractor is to submit Day works sheets to the Architect's site office.

These will then be distributed to respective Consultant disciplines for review, checking, verification and approval. Submittals will not be accepted if Day works sheets are incorrectly filled out or submitted unsigned. Submittals will not be accepted which, in the opinion of the architect and/ or engineer, do not accurately reflect actual Day works done.

5.26 Formats

Day works sheets shall be in standard format to be approved by the Architect. The format is to run on a weekly basis. As a minimum form shall include:

- ✓ Date
- ✓ AI reference
- ✓ Hours worked
- ✓ Cost column
- ✓ Labor type/ trade
- ✓ Name of person
- ✓ Work done by room number and/ or system
- ✓ Signature and date of the contractor foreman
- ✓ Architect approval signature and date box

5.27 The Contractors Authorization

The Contractor shall provide the Architect with names and position/ responsibility of each person authorized to sign Day works sheets.

5.28 Consultants Authorization

The senior resident architect, senior resident engineer or designated counterparts are authorized to sign Day works sheets.

5.29 Distribution

All approved Day works sheets are to be returned to the Architect and thence to the Quantity Surveyor at regular intervals, at least monthly. Rejected Day works sheets will be returned to the Contractor not later than 14 working days after the date of receipt by the Architect.

5.30 Tropicalization

Indoor parts may alternatively have chromium or copper nickel plating or other approved protective finish. Steel screw, where used, shall be chromium plated or, when plating is not

possible shall be of stainless-steel. All nuts, bolts, and washers, which are exposed to the weather or in contact with moisture, shall be of stainless steel to BS 6105. All nuts and bolts shall be of uniform thread and conform to Isometric sizes.

Adhesive shall be specially selected to ensure the use of types, which are impervious to moisture, resistant to mold growth and not subject to the ravages of insects.

Fabrics, cork, paper, and similar materials, which are not being impregnated, shall be treated with an approved fungicide or so treated to make it resistant to the ravages of insects.

5.31 Method of Fixing

Unless otherwise approved, all fixing of hangers and brackets shall be done by means of expansion anchor/ raw-plug. Wooden and plastic plugs will not be allowed.

Explosive charge fixing devices shall only be used when and where approved by the Local Authorities and the Architect. In which case, the manufacturer recommended procedures of fixing should be strictly adhered to.

Fixing to structural steel shall be by means of proprietary clamps. The structural steel shall not be drilled or welded without approval.

5.32 Comment by the Bidder

Any comments by the bidder on the efficacy of the design, discrepancies, the adequacy of plant room space, the availability of plant, materials and labour and the time required for the completion of the work shall be made at the time of returning the tender.

5.33 Protection of Existing Structures

All existing water and other pipes, electric conduits, sewers, drains and other structures shall be carefully supported and protected from injury by the Contractor and in the case of injury they shall be restored by him without additional compensation to the satisfaction of the Superintending Officer.

5.34 Dissimilar Metals

Dissimilar metals shall be separated from direct contact with each other. Supply necessary gaskets dielectric couplings and the like. Copper shall not be used upstream of galvanized materials. Fastenings shall be equivalent or exhibit better corrosion resistance than the materials jointed or held.

5.35 Radio Frequency Interference

All equipment supplied under this contract shall be equipped with radio frequency interference suppression in accordance with the BS Standard applicable to that equipment.

5.36 Fire Stopping

An approved type fire-stopping system shall be used to seal all openings through walls and floors against the spread of fire and hot gases after the installation of cables, pipes and ducts as well as abandoned openings.

The fire stopping system should be easily applied, in tumescent and resistant to water, solvents, acids, humidity and other industrial influences. The applied thickness shall give a fire rating equivalent to that afforded by the partition or floor in which the opening is made.

Where necessary, a specialist shall be employed and paid by the contractor to carry out the fire stopping works.

5.37 Proprietary Computer Software Licensing

All proprietary software supplied with any computer equipment shall be properly licensed. A licensed agreement between the Employer and the vendors of the proprietary software packages shall be included in this contract and all cost and royalties shall be paid by the contractor.

5.38 Protection and Surface Finishes

Protection against corrosion, deterioration, absorption of moisture and the like shall be provided for all materials and equipment and shall be finished in approved colors and qualities of finishes.

Galvanizing shall be carried out in accordance to BS729, but shall achieve the following thickness of zinc coating:

Damaged galvanizing shall be touched up with one coat of zinc rich paint.

All materials exposed to view shall be cleaned, degreased, and painted with a suitable primer, undercoat and two finish coats to a total dry film build-up of not less than 0.1mm. Finish coat color shall be as directed by the Architect.

Concealed steel parts shall be cleaned, degreased, primed, and painted with one undercoat, including steel pipe to be insulated.

5.39 Galvanized Surfaces

Shall be cleaned with a suitable pre paint treatment, immediately followed by one coat of galvanized iron primer, followed by one coat of undercoat in contrasting color, and one final coat to the specified color.

For external galvanized surfaces and pipe, the contractor shall provide a paint system with suitable technical support to demonstrate that the oxidation rate of zinc will not be accelerated by the proposed painting system.

The total dry paint film build up shall be 80 microns. The final coat need not be applied to externally insulated sheet metal duct work.

Touching up to damaged areas shall be zinc rich powder-based paint to give equal protection to undamaged areas.

5.40 Mild Steel Surface

Pre- treatment shall be as per above, followed by one coat of anti-rust primer, 1 coat of metallic lead primer (or equal) in a contrasting color and one finishing coat of super enamel for a total paint build-up of 80 microns.

5.41 Stainless Steel, Copper

Need not be painted, except for the identification of its use.

5.42 Concealed Work

Pipe-work and ductwork concealed in walls shall be thoroughly cleaned and primed; finishing coats need not be applied.

5.43 Areas with no Ceiling

For areas with no ceiling, the finishing coat shall be to the Architect's selected color.

5.44 Warranty, Maintenance and Support

5.44.1 Warranty

- ✓ Comprehensive warranty shall be provided for a period of One (01) year from the date of handing over. It shall include free maintenance service, free provision of spare parts, tools, etc. This condition shall also apply towards the software delivered by successful the Contractor along with the system.
- ✓ All cabling works (passive) shall have 20 years system warranty issued by the manufacturer and all other works (active) shall have 01 year of comprehensive warranty.

5.44.2 Maintenance and support

- ✓ The bidder shall provide the One (1) year free onsite maintenance service from the date of handing over and such service include troubleshooting, repair and replacement of all equipment, parts and spares as and when required within 04 Hours.
- ✓ Bidder shall propose and implement an appropriate Failure Reporting, Analysis and Corrective Action System (FRACAS) with prescheduled quarterly reliability operational assessments.
- ✓ The bidder shall assign full-time/part-time technical supervisors to the Works as required for the relevant Systems of this ELV systems to assist the Employer in operating all systems for the duration of the Contract Period with 24x7 service support.
- ✓ The Tenderer shall be responsible for providing full operation, maintenance and repair services for all Systems and Works, for the duration of the Contract Period.
- ✓ Repair services including an emergency repair and replacement of all equipment, parts and spares as and when required within Next Business Day of a call out from the Employer or Engineer for whatever issue or cause.

- ✓ The provision of all consumables, lubricants, spare parts, and replacement parts shall be maintain as required.
- ✓ In the event that maintenance, repair or call out services are made necessary by abuse, misuse or other causes beyond the control of the Tenderer, the Tenderer shall provide such maintenance and repair and call out services and the Tenderer shall be reimbursed his reasonable authenticated cost by the Employer.
- ✓ The Tenderer shall remain responsible for the effective and efficient performance of the Systems with the all equipment for the maintenance and repair thereof throughout the Contract Period
- ✓ The Tenderer shall provide telephone hotline support for the Employer throughout the maintenance period and Tenderer shall undertake to answer all questions on all technical matters of the Systems informed by nominated persons of the employer.
- ✓ The Tenderer shall undertake to install new releases of all software packages installed under the Contract within maintenance period at no extra cost. Every installation shall be preceded by installation on a test site. The Employer shall validate the new functions over a period of time and after receiving approval the Tenderer shall install and test.
- ✓ The Tenderer shall properly maintain the maintenance register up-to-date, which shall be used to log all adjustments and any repair works with all maintenance information, during maintenance period.
- ✓ Annual Maintenance Contract (AMC) agreement should be provided to be processed after completion of warranty period.

#	Item	Maintenance Period	Required Maintenance
1	LAN		
	CAT6 U/UTP Cables	3 Months	Visual Inspection Cleaning
	Fiber Optic Cable	3 Months	Visual Inspection Cleaning
	Patch panel U/UTP	3 Months	Visual Inspection Cleaning
	Free Standing/ Wall mounted Enclosure	3 Months	Visual Inspection Cleaning Ventilation System Working Condition Check

	WI-FI Access Points	3 Months	Visual Inspection Cleaning
2	PABX		
	IP Telephones	3 Months	Any Extension number change Visual Inspection Cleaning
	PoE/ Non PoE Switches	3 Months	Check for firmware updates Performance Testing Security Updates Visual Inspection Cleaning Configuration Backup
	UPS	3 Months	Visual Inspection Battery Backup Check Cleaning
3	CCTV System		
	CCTV Cameras	3 Months	Visual Inspection Cleaning Angle Adjustment Check Firmware update
	NVR	3 Months	Check for firmware updates Performance Testing Security Updates Configuration Backup Cleaning
	CCTV Display Panels	3 Months	Cleaning, Visual Inspection
	Monitoring workstation	3 Months	Check Firmware update Cleaning Visual Inspection
4	Access Control System (ACS)		
	Biometric Reader	3 Months	Visual Inspection Time Synchronization Check Firmware updates
	Door Controller	3 Months	Visual Inspection Time Synchronization Check Firmware updates
	Exit push Button Switch	3 Months	Visual Inspection Cleaning
	Electro Magnetic Lock	3 Months	Visual Inspection Cleaning Contact force inspection
5	PA and Background Music system		
	Power/ Mixing Amplifier, EVAC Compliant	3 Months	Cleaning Visual Inspection Sound adjustment
	Voice Alarm Controller/ Message Manager/ Weekly Timer	3 Months	Visual Inspection Time Synchronization Check Firmware updates

	Microphones	3 Months	Cleaning Sound Performance test
	Speakers	3 Months	Cleaning Sound Performance test
	Volume Controller Fail Safe	3 Months	Visual Inspection

1.46 List of Preferred/Recommended Manufacturers ICT Systems

#	Item	Manufacturers ICT System
1	Structured Cabling system (CAT6)	CommScope, Panduit, PremiumLine, Nexans, Molex OR EQUIVALENT
2	Data Switches	CISCO, HP, Ruckus OR EQUIVALENT
3	CCTV IP Surveillance System	Axis, Honeywell, Bosch, Hanwa OR EQUIVALENT
4	Door Access Control System	Suprema, Bosch, Tyco, HID OR EQUIVALENT
5	Voice Evacuation, Public Address and pipe Music System, AV	TOA, Honeywell, Bosch OR EQUIVALENT

Note:

Reference made here to certain manufacturers' products and items identified by registered trademarks. This has been done for the sole purpose of defining and establishing standards of quality and performance and not with the intention of restricting the procurement of materials or fittings to a particular manufacturer. The Tenderer shall ensure that all products, even though they are from the above list, meet the specification requirement and Engineers approval.

2 SPECIFICATIONS FOR STRUCTURED CABLING SYSTEM (SCS) AND LOCAL AREA NETWORK (LAN)

2.1 Common Conditions for passive system

- i. Total passive system should be based on single brand and bidder should provide Manufacture Authorization Letters (MAL) along with 25 year or more system warranty from principal suppliers.
- ii. All passive system should certify with valid calibrated Fluke testers and all report in FL format should be provided.
- iii. Warranty certificate for 5 years as stated in specification.

2.2 CAT6 U/UTP cables

Minimum Specification

- i. Twisted pair cable (U/UTP), 8 conductor, solid stranding, 23 AWG bare copper and LSZH insulated wire
- ii. Shall support IEEE 802.3:10BASE-T, IEEE 802.3u:100BASE-T, IEEE 802.3ab:1000BASE-T, IEEE 802.3an:10GBASE-T
- iii. Operating frequency range shall be 0-250 MHz

2.3 CAT6 24 port patch panel U/UTP

Minimum Specification

- i. 19" based hardware per EIA-310(1U rack height)
- ii. CAT 6 standards
- iii. Gold Plated Copper
- iv. Bandwidth of 250 MHz or higher for each port
- v. Rear cable management bar
- vi. Each port must accept 4 pairs of solid pure copper 23 AWG conductors
- vii. Patch panel shall be metal and black in colour

2.4 8 Core Fiber Optic Cable – Indoor (OM3)

Minimum Specification

- i. OM3 Fiber Classification
- ii. Eight (8) core indoor type tight buffered fiber cable shall be capable of withstanding, without degradation in performance, Temperatures in the range 0°C to 70°C
- iii. The cable shall comply with all safety and fire regulations
- iv. The cables to be laid shall contain fibers with the following specifications: Multi Mode (50/125µm)

v. Support for 1Gbps/10Gbps/40Gbps

- vi. The multimode fibers shall be tested at both 850 nm and 1300 nm wavelengths as per EIA/TIA 568 C.3 or ISO/IEC 11801 standards
- vii. All tests shall be performed using laser light sources
- viii. Maximum attenuation: less than 3.5dB/km (at 850 nm), less than 1 dB/km (at 1300nm)
- ix. Min tensile strength during installation shall be 600 N
- x. Min tensile strength during operation shall be 200 N
- xi. 20/25 years systems warranty

2.5 Patch leads (1m or 2m) - Multi mode fiber optic with LC-to-LC interface (OM3)

Minimum Specification

- i. OM3 Fiber Classification
- ii. Length of 1 or 2m multimode fiber (50/125µm) duplex patch leads
- iii. LC interface for both ends
- iv. Shall match with fiber cable and core diameter
- v. Support for 1Gbps/10Gbps/40Gbps
- vi. The multi-mode fibers shall be tested at both 850 nm and 1300 nm wavelengths as per EIA/TIA 568 C.3 standards
- vii. LSZH (Low Smoke Zero Halogen) fire ratings
- viii. All patch leads shall be factory made and printed with length, standard, brand and model number
- ix. 20/25-year Systems warranty

2.6 Cable Tray including all required accessories

Minimum Specification

- i. Highly scratch resistant, durable powder coat
- ii. Thickness ≥ 1.5 mm
- iii. hot-dip galvanized (after fabrication) according to BS EN ISO 1461 or Zn-Al with powder coating
- iv. All components welded for rigidity and strength
- v. Full range of integrated ancillaries and supports
- vi. Safer to handle and no damage to cables
- vii. All systems are supplied and installed complete with fastenings
- viii. Mounting brackets and fixing bolts
- ix. All required accessories from all type of cable ladders
- x. 5 years warranty against corrosion

2.7 Free Standing Enclosure 42U/29U 19" cabinets

Minimum Specification

- i. 42 U/29U x 19"[800 (w) x 42U/33U (h) x 800/600 (d)]
- ii. Front lockable perforated door, Steel side and perforated back door with louvers
- iii. Split type perforated rear doors open in the middle
- iv. 2 x 42U Cable Ladder
- v. Two Vertical cable managers for maintain bending radius of patch cords for front
- vi. 1 x 230V AC Low noise brushless Fan Plates (3 fans in each plate)
- vii. 2 x Removable Louver Plate for side panels
- viii. 2 x Cable Gland Plates
- ix. Velcro Straps for cable tie
- x. 1 Cable Entry
- xi. Fixed tray for all switches
- xii. 2 x 12/6-way vertical 13A IEC C-13 Type Power Distribution Unit (PDU) (bidder shall provide 2 nos. of PDU for server room Racks)
- xiii. Power cord shall connect to the UPS output/power socket on wall directly
- xiv. M6 Screws, Washers, M6 Cage Nuts and accessories
- xv. Black in colour
- xvi. Quick Release perforated doors and side panels, fully horizontally adjustable front and rear profiles
- xvii. Thermal transfer laminated labels for cable management
- xviii. Proper grounding kit to connect nearest electrical consumer unit grounding bar All required earth cables and accessories shall be included
- xix. Some racks might require to assemble at site in selected rack locations which has limited space (width) in the entrance door to the room
- xx. 5 years comprehensive warranty

2.8 Wall Mounting Enclosure 12/16/19U 19" cabinets

Minimum Specification

- i. Dimension 1 U x 19" [600(w) x 24U/12U (h) x600(d)]
- ii. 1.5 mm strong sheet steel with high load capacity, powder coated Front lockable perforated door
- iii. 2 x 6/10/12U Cable Ladder
- iv. 1 x 230V AC Low noise brushless Fan Plates (3 fans in each plate)
- v. 2 x Cable Gland Plates
- vi. Velcro Straps for cable tie
- vii. Cable Entry and rear cable routing accessory kit
- viii. Fixed tray for all switches
- ix. M6 Screws, Washers, M6 Cage Nuts and accessories
- x. 1 x 6way horizontal 13A IEC C-13 Type Power Distribution Unit (PDU) connected to the UPS output directly
- xi. Power cord shall connect to the UPS output/power socket on wall directly
- xii. Black in colour
- xiii. Quick Release perforated doors, fully horizontally adjustable front
- xiv. Thermal transfer laminated labels for cable management

- xv. Proper grounding kit to connect nearest electrical consumer unit grounding bar All required earth cables and accessories shall be included
- xvi. 5 years comprehensive warranty

2.9 Common Conditions for Active system

- i. Active equipment principle should have references in government sector more than 5 years with similar nature implementations
- ii. Active equipment principle should be leader in Gartner report for last 3 years
- iii. In the core, active equipment should be based on dual home architecture and all access switches and core switches should be stackable and necessary stacking cables should be provided
- iv. All core and access switches Operating systems based on modular architecture and should allow upgrade and reboot each module without rebooting
- v. Should be cloud manageable and applicable license should include
- vi. LAN and Wi-Fi should manage through single dashboard
- vii. Should have analytical through the management tool from day one
- viii. UAT test case should submit along with tender

2.9.1 8 x 10G SFP+, 4SFP+ (Uplink), Gigabit Ethernet ports Core Switch Full L3

Minimum Specification

- i. Layer-3 Switching Support Should support Static IP routing, should support Routing for directly connected IP subnets, should support Access Control List (ACL), Should be able to upgrade to support RIPv2, OSPF in the future
- ii. Layer-2 Switching Support Should provide Layer-2 Switching across all IPV4 and IPV6 protocols, Total Switching Capacity should be at least 740Gbps or higher, should support Jumbo frames
 - Network Interfaces Switch should have 8 x 1/10GbaseX and uplink modules including 4 x 25GbE or 40GbE
 - Features Should support at least 4000 IEEE 802.1q VLANs or more and should have full layer-2 manageable features, should support IEEE 802.3ad link aggregation, should support IEEE 802.1p L2 Prioritization features and Flow Control, should support at least 110k MAC addresses, should support IEEE 802.1x Port-Based, 802.1X multiple supplicants, 802.1X with VLAN assignment, 802.1X with authentication bypass access based on host MAC address, 802.1X with VoIP VLAN support, dynamic ACL based on RADIUS attributes, 802.1X Supported Extensible Authentication Protocol (EAP) types: Message Digest 5 (MD5), Transport Layer Security (TLS), Tunneled TLS (TTLS), Protected Extensible Authenticated Protocol (PEAP), MAC authentication (RADIUS), Control plane DoS protection, Radius functionality over IPv6 for authentication, authorization, and accounting (AAA), DHCPv6 snooping Authentication, The Switch Hardware Should Support IEEE 802.3az-2010 Energy Efficient Ethernet (EEE) standard
- iii. Switch Manageability the Switch management features should consist of CLI and GUI (Web Based) comprehensive management feature with SNMP Support
- iv. Operating Temperature Should be from 0°C to 40°C
- v. Power Requirement Should Operate on an AC Input Voltage of 110~240V and with an input frequency of 50Hz

- vi. Should have dual power supply should load-sharing, hot-swappable, and field-replaceable power supplies
- vii. Mounting Should be Industrial Standard 19" Rack Mountable with all relevant accessories for rack mounting
- viii. Should include necessary 10Gbps MM Transceivers support up to 300metres

2.9.2 48 Port 10/100/1000 PoE+ (740w/370w) Switch + 2 SFP+ Gigabit Uplinks (L2) (QoS Enabled) including 850nm fibre modules with LC interface

Minimum Specification

- i. Managed Layer 2 Switch with 24 10/100/1000 Mbps POE Ports (740w/370w)
- ii. Support IEEE 802.3: 10BASE-T, IEEE 802.3u: 100BASE-T, IEEE 802.3ab: 1000BASE-T, IEEE 802.3z: IEEE 802.3af: PoE, IEEE 802.3at: PoE+, IEEE 802.3x: Pause frames/flow control, IEEE 802.3ad: Link Aggregation Control Protocol (LACP)
- iii. Manual Configuration of speed and duplex mode in all ports
- iv. Switching capacity – 176Gbps
- v. Layer 2 QoS
- vi. Should Support at least 1000 IEEE 802.1Q VLANs, Jumbo frames and a MAC address table greater than 12k
- vii. IEEE 802.1D: Spanning Tree Protocol and IEEE 802.1w: Rapid Spanning Tree Protocol (RSTP) must be followed
- viii. CLI through Telnet or Web based GUI Configuration (Text Based) Management with at least two privilege levels (read only/ read & write)
- ix. Password protection for all privilege levels
- x. Traffic Prioritization with IEEE 802.1p compliance and support for traffic analysis on ports
- xi. 19" rack-mountable
- xii. 230V AC 50±5Hz power supply
- xiii. Switch should support and configured for IP cameras
- xiv. Shall support IGMP V2, V3 Multicasting for IPTV

2.9.3 24 Port 10/100/1000 PoE (370w) Switch + 2 SFP+ Gigabit Uplinks (L2) (QoS Enabled) including 850nm fibre modules with LC interface

Minimum Specification

- i. Managed Layer 2 Switch with 24 10/100/1000 Mbps POE Ports (370w)
- ii. Support IEEE 802.3: 10BASE-T, IEEE 802.3u: 100BASE-T, IEEE 802.3ab: 1000BASE-T, IEEE 802.3z: IEEE 802.3af: PoE, IEEE 802.3at: PoE+, IEEE 802.3x: Pause frames/flow control, IEEE 802.3ad: Link Aggregation Control Protocol (LACP)
- iii. Manual Configuration of speed and duplex mode in all ports
- iv. Switching capacity – 128Gbps
- v. Layer 2 QoS
- vi. Should Support at least 1000 IEEE 802.1Q VLANs, Jumbo frames and a MAC address table greater than 12k
- vii. IEEE 802.1D: Spanning Tree Protocol and IEEE 802.1w: Rapid Spanning Tree Protocol (RSTP) must be followed

- viii. CLI through Telnet or Web based GUI Configuration (Text Based) Management with at least two privilege levels (read only/ read & write)
- ix. Password protection for all privilege levels
- x. Traffic Prioritization with IEEE 802.1p compliance and support for traffic analysis on ports
- xi. 19" rack-mountable
- xii. 230V AC 50±5Hz power supply
- xiii. Switch should support and configured for IP cameras
- xiv. Shall support IGMP V2, V3 Multicasting for IPTV

2.10 10G SFP+ Module

Minimum Specification

- i. 10G SFP+ transceiver, LC SR 300m
- ii. Should in same switch brand

2.11 Indoor Wi-Fi Access Points

2.11.1 Common Conditions for WiFi

- i. Active equipment principle should have references in government sector more than 5 years with similar nature implementations.
- ii. Active equipment principle should be leader in Gartner report for last 3 years.
- iii. Should support for WiFi6
- iv. Should be form same brand as switches.
- v. Heat map should provide along with the bid and post implementation active heat map should provide through industry standard Wi-Fi analyser
- vi. UAT test case should submit along with tender
- vii. Should have analytical through the management tool

Minimum Specification

- i. 802.11b & g, 802.11n, 802.11ac and 802.11ax
- ii. Ceiling mount
- iii. Dual Band - 2.4 and 5 GHz
- iv. 4x4 MIMO
- v. 1 x 10/100/1000Base-T ports POE support
- vi. Directional antenna type
- vii. Bandwidth
 - a. 860 Mbps in the 5 GHz band
 - b. 300 Mbps in the 2.4 GHz band
- viii. -50 to -70 dB minimum signal strength at the edge of the coverage area.
- ix. IEEE 802.1x support
- x. Centralized management, visibility, and control and support real time web-based diagnostics, monitoring & reporting
- xi. VLAN tagging (802.1q)
- xii. IEEE 802.1p QOS
- xiii. Backward compatible with 802.11b and g devices
- xiv. Shall be compatible with proposed wireless controller
- xv. WEP, WPA Pre-Shared Key (WPA-PSK), WPA2-PSK

- xvi. Support up to 12 BSSIDs per radio and recommended to configure only maximum 4 SSIDs.
- xvii. Shall include other mounting accessories

2.12 Wi-Fi Controller

Minimum Specification

Wi-Fi Controller shall be provided to manage all access points and issue user credentials based on employee database from the HRIS system. If possible, it is acceptable to have the Wi-Fi controlling embedded to the Wi-Fi Access Points.

2.13 Online UPS

Minimum Specification

- i. Capacity - 1kVA/3kVA/5kVA (Online)
- ii. Input Voltage - 230 ± 10 V
- iii. Output Voltage - 230 ± 10 V
- iv. Full-load Efficiency - $\geq 90\%$
- v. Frequency - 50-60 Hz
- vi. Power generator compatible
- vii. Typical battery backup time - 10 minutes for full load
- viii. Power failures, Battery discharge, Poor battery, abnormal UPS behaviors shall be alarmed through Audible Alarms and Lighting (LEDs)
- ix. Mounting – When uses to power rack mounted equipment, UPS shall also be racking mountable type

2.14 Private Automatic Branch Exchange System (PABX)

2.14.1 General Requirements:

The system should be an IP PABX capable of supporting up to 160 IP telephone extensions and 8 SIP lines.

The system should have the ability to support multiple simultaneous calls and should have advanced call features such as call forwarding, voicemail, conference calling, and auto-attendant.

The system should be scalable and flexible, allowing for additional extensions and lines to be added as needed.

The system should support remote management and maintenance capabilities.

The system should be compatible with standard SIP phones and should support a wide range of IP phone models.

The system should be easy to install, configure, and operate.

2.14.2 IP Telephones:

The system should support a wide range of IP phone models, including desk phones, wireless phones, and softphones.

The IP phones should have high-quality audio and be user-friendly. The desk phones should have a minimum of 8 programmable buttons for quick access to features and contacts.

The IP phones should support advanced call features such as call forwarding, voicemail, conference calling, and auto-attendant.

2.14.3 Executive IP Telephones:

The system should support a wide range of IP phone models, including desk phones, wireless phones, and softphones.

The IP phones should have high-quality audio and be user-friendly, catering to the executive's needs for clear communication and efficient operation. The executive desk phones should have a minimum of 12 programmable buttons for quick access to features and contacts.

The IP phones should support advanced call features such as call forwarding, voicemail, conference calling, and auto-attendant, providing executives with seamless connectivity and enhanced productivity.

2.14.4 SIP Lines:

The system should support a minimum of 8 SIP lines.

The SIP lines should be high-quality and reliable, with sufficient bandwidth to support multiple simultaneous calls.

The system should support a wide range of SIP trunk providers.

2.14.5 Network Infrastructure:

The system should be connected to a reliable and high-speed network infrastructure capable of supporting the required number of IP telephone extensions and SIP lines.

The network infrastructure should be designed to minimize downtime and ensure reliable communication.

2.14.6 Support and Maintenance:

The system should be supported by the manufacturer or authorized dealer and should include a warranty and ongoing support and maintenance.

The manufacturer or authorized dealer should provide training and technical support to ensure smooth operation of the system.

3 SPECIFICATIONS FOR IP CCTV SYSTEM

3.1 2MP Indoor Dome camera

Minimum Specification

- i. 2MP indoor dome
- ii. Support 30 fps@1920x1080
- iii. Low Light Color Cameras (Shall produce color images at nighttime based on the low light performance and image processing capabilities)
- iv. Fixed lens 3.6/6mm
- v. Day and Night Indoor Camera with Built-in IR illuminators
- vi. 1/3" CMOS/ MOS, Progressive scan
- vii. Minimum Illumination Color ≤ 0.3 lux, B/W ≤ 0.05 lux @F2.2
- viii. WDR
- ix. Digital zooming
- x. H.265, H.265+, H.264, M-JPEG or MPEG-4
- xi. 2 video Streams
- xii. Automatic, IR-Corrected / IR-Cut filter
- xiii. Login Authentication, HTTPS encryption
- xiv. IPv4/v6
- xv. HTTP, HTTPS, FTP, DNS, DynDNS, QoS, RTSP, RTP, TCP, SNMP, UDP, IGMP, RTCP, ICMP, DHCP, ARP
- xvi. PoE (IEEE 802.3af)
- xvii. ONVIF
- xviii. IK10 Vandal Resistant
- xix. Video motion detection and active tempering alarm
- xx. 1 Year comprehensive warranty

3.2 4MP Outdoor bullet camera

Minimum Specification

- i. 4MP Outdoor Bullet
- ii. Support 30 fps@1920x1080
- iii. Low Light Color Cameras (Shall produce color images at nighttime based on the low light performance and image processing capabilities)
- iv. Fixed lens 3.6/6mm
- v. Day and Night Indoor Camera with Built-in IR illuminators
- vi. 1/3" CMOS/ MOS, Progressive scan
- vii. Minimum Illumination Color ≤ 0.3 lux, B/W ≤ 0.05 lux
- viii. WDR
- ix. Digital zooming
- x. H.265, H.265+, H.264, M-JPEG or MPEG-4
- xi. 2 video Streams
- xii. Automatic, IR-Corrected / IR-Cut filter
- xiii. Login Authentication, HTTPS encryption

- xv. HTTP, HTTPS, FTP, DNS, DynDNS, QoS, RTSP, RTP, TCP, SNMP, UDP, IGMP, RTCP, ICMP, DHCP, ARP
- xvi. Two-way (Only for Fire Exits)
- xvii. PoE (IEEE 802.3af)
- xviii. ONVIF
- xix. IP67/68 for Outdoor Installations
- xx. IK10 Vandal Resistant
- xxi. Video motion detection and active tempering alarm
- xxii. 1 Year comprehensive warranty

3.3 4MP Outdoor bullet camera (People Counting)

Minimum Specification

- i. 4MP Outdoor Bullet
- ii. Support 30 fps@1920x1080
- iii. Low Light Color Cameras (Shall produce color images at nighttime based on the low light performance and image processing capabilities)
- iv. Fixed lens 3.6/6mm
- v. Day and Night Indoor Camera with Built-in IR illuminators
- vi. 1/3" CMOS/ MOS, Progressive scan
- vii. Minimum Illumination Color ≤ 0.3 lux, B/W ≤ 0.05 lux
- viii. WDR
- ix. Digital zooming
- x. Video analytics – People up down counting
- xi. H.265, H.265+, H.264, M-JPEG or MPEG-4
- xii. 2 video Streams
- xiii. Automatic, IR-Corrected / IR-Cut filter
- xiv. Login Authentication, HTTPS encryption
- xv. IPv4/v6
- xvi. HTTP, HTTPS, FTP, DNS, DynDNS, QoS, RTSP, RTP, TCP, SNMP, UDP, IGMP, RTCP, ICMP, DHCP, ARP
- xvii. Two-way (Only for Fire Exits)
- xviii. PoE (IEEE 802.3af)
- xix. ONVIF
- xx. IP67/68 for Outdoor Installations
- xxi. IK10 Vandal Resistant
- xxii. Video motion detection and active tempering alarm\
- xxiii. 1 Year comprehensive warranty

3.4 Network Video Recorder (NVR)

Features	Minimum Requirement
Camera capacity	88
Recording Resolution	12MP (Max)

Recording Speed	25fps per camera @720p
Storage Memory	30 days continuous
Video compression	H.265, H.265+, H.264, MPEG-4 or Motion JPEG
Image Processing	Color Image Processing at Night Vision
RAID Level	RAID 5
USB Ports	2 x USB 2.0 / 3.0
Network interface	Dual (Redundant) Gigabit Ethernet
Network Protocols	TCP/UDP/HTTP/DHCP/DNS/ARP/ICMP/NTP
Expandability	Yes
System Compatibility	ONVIF
Storage	SCSI and iSCSI
warranty	1 Year

3.5 Video Management Software

Minimum Specification

Software Features	Minimum Requirement
Add Camera	Manual and Smart Search
Video compression	H.265, H.265+, H.264, MPEG-4 or Motion JPEG
Display Mode	Live/Playback/Full Screen/Original Aspect Ratio
Image Processing	Color Image Processing at night vision.
Snapshot	Video snapshot in JPEG
Event Search	All/Time/Channel/Event Type/Event ID
Playback Controls	Play/Pause/Stop/Forward (speed adjustable)/Rewind (speed adjustable)/ Frame by Frame/Event by Event
Recording Mode	Motion based/Manual/Continuous/Scheduling/Event
Recording Schedule	Time based/ Manual select /Profile based
Event Detections	System Events/Camera Events
Privileges	Live View/Playback/ System Configuration/Camera Configuration/ Recording Configuration/Event Configuration/System Maintenance/ Digital zoom in preview and playback
E-Map	Event Display on E-MAP or similar

Smart Alert Functions	Enlarge camera view/Warning sound/Pop-up/ Email / Start recording / Send video to predefined place.
Remote PTZ control.	Yes
System Log	Operation, System, Network Error, Recorder Error, Alarm.
Expandability	Yes
User Management	Registration up to: 20 users User Levels: 3
Security Method	User Authentication(User ID and Password), Host Authentication (IP Address)
Language	English

3.6 CCTV Display Panels (55")

Minimum Specification

- i. Borderless configuration is preferred
- ii. Aspect Ratio : 16:9
- iii. Light Source Type : LED
- iv. Resolution : 4k
- v. Input Terminals : HDMI, DVI-D, VGA, Stereo Mini-Jack, RS-232C
- vi. Output Terminals : Stereo Mini-Jack, DVI-D, RS-232C
- vii. External Control : RJ45 or RS232C
- viii. Wall-mounting : Compatible with VESA standard bracket
- ix. Industrial grade display panels with 24/7 rated operation
- x. 1 Year comprehensive warranty

3.7 Monitoring workstation with UPS and other necessary equipment with monitoring software

Minimum Specification

- i. Server with DVD-RW
- ii. Intel i7, 512GB HDD SSD, 16GB RAM, Server Grade Computer with OS or Latest Windows OS (licensed)
- iii. Dedicated 4GB graphic card compatible with resolutions
- iv. UPS 1.2KVA
- v. Screen
 - a) Screen size 32"
 - b) Panel type LED
 - c) Response rate 2ms
- vi. 1 Year comprehensive warranty

4 SPECIFICATIONS FOR ACCESS CONTROL SYSTEM (ACS)

4.1 Biometric Reader (Card + Finger) (For ACS)

Features	Minimum Requirements	
Storage	Fingerprint templates	10,000
	Transaction	50,000
Enrollment & Verification	Method	Fingerprint (1:1, 1: N) & Card
	Fingerprint placement	Any angle
	Verification time(sec)	<2
Card Technology	Smart Card-RFID	13.56 MHz contactless smart card - iCLASS, MIFARE DESFire EV1
	Encryption method	Triple-DES, 128bit AES encryption or higher
Communications	Method	TCP/IP, RS485, Wiegand or higher
	Baud rates	9600/19200
Operating Environment	Temperature (Celsius)	0-45
	Humidity (%)	20-80
	IP Rating	Min: IP55
Fingerprint Sensor	Optical 500dp	
Language Support	English	
Indicator	Multi-color LED or multi-tone buzzer	
Power	PoE or PoE+	
Warranty	1 Year	

4.2 Door Controller

Features	Minimum Requirements
Door Access Controller	Intelligent Single/Double door controller (or Four door controller as applicable)
Interface	Ethernet (RJ45)
Communication Methods	TCP/IP, Wiegand or higher
Card Holder/ User Database	10,000
Offline Transactions	8,000
Reader Ports	1/2/4 Ports
Inputs	Inputs Support 1/2/4 Doors (Door Contact, Magnetic Lock etc.)

Outputs	Support 1/2/4 Doors (Relay outputs)
Housing	Wall mount enclosure
Power	PoE or PoE+ (Battery backup shall be installed with controller for 24Hrs operation)
Warranty	1 Year

4.3 Exit Push Button Switch– for Building operator

Features	Minimum Requirements
Door Opening Time (sec)	0.5 – 20 (adjustable)
Operating Temperature (Celsius)	0 - 45
Operating Humidity (%)	20 - 80
Warranty	1 Year

4.4 Electro Magnetic Lock– for Building operator

Features	Minimum Requirements
Type	Electromagnetic door lock
Holding Force	750 lbs. per single door or higher according to door weight.
Auto-Relocking Time Delay	Adjustable
Operating Temperature (Celsius)	0-45
Warranty	1 Year

4.5 Lift Access Control

Minimum Specification

- i. Lift access control system must be installed in all lifts of the building.
- ii. The system must be designed to restrict access to only authorized personnel, such as tenants, employees, and visitors.
- iii. The system must use a combination of access control methods, such as proximity cards PIN codes, biometric verification, or a combination thereof.
- iv. The system must be able to store access control data for a minimum of one year and be able to generate reports on access attempts, successful and unsuccessful entries, and other related data.

- v. The system must have a backup power supply to ensure continuous operation during power outages.
- vi. The system must be designed with fail-safe measures to ensure uninterrupted operation and prevent unauthorized access attempts.
- vii. The access control system must be designed and installed by experienced and qualified professionals.
- viii. The access control system must be tested and commissioned before the building is occupied, and training provided to building management and security personnel on the use and operation of the system.

5 SPECIFICATIONS FOR PA SYSTEM

5.1 General Specifications

1. PA Head end diagram is only a guidance for the contractor. The Contractor shall provide their product specific designs for head end including all the core items indicated in the drawing.
2. The system should be fully **EVAC** (Emergency Voice Evacuation) complied. All the Equipment, cables and accessories should be complied with local and NFPA fire regulations.
3. When a voice announcement, other areas BGM (Background Music) should not be disturbed. System should be arranged accordingly.
4. BGM system should be overridden by fire message/Announcement or any other paging.
5. Main audio cabinet to be provided at the fire commanding center for this audio system included but not limited to following,
 - Amplifier Monitor Panel
 - PABX interface module (for Announcement by PABX)
 - Message Manager/Weakly Timer
 - Fire Interface
 - Main Control Unit (Networks Supported)
 - Pre/Mix Amplifier
 - Power Amplifiers as adequate with 30% Spare, 500W x (N+1)
 - Power Supply Unit (including standalone battery)
 - Cabling within the main audio cabinet
 - Free standing racks including power bars - 42U

5.2 Power/Mixing Amplifier, EVAC Compliant

Minimum Specification

The power amplifier shall be provided with a nameplate indicating power rating to satisfy design coverage, SPL (Sound Pressure level) requirements, and reserve capacity requirements. Power amplifiers shall conform to EIA SE-101 and to the following criteria. **N+1** Arrangement should be available.

- i. Output Power 200W
- ii. THD Less than 0.4%
- iii. Temperature-controlled forced front-to-back ventilation
- iv. Power Requirement 230±10V AC, 50/60Hz
- v. Output Voltage per Channel 100V Line
- vi. Frequency response: 20 Hz to 20 kHz flat ±1 dB
- vii. S/N Ratio (A weighted) 100dB
- viii. Crosstalk at 10 kHz (A weighted) 70dB
- ix. Damping Factor (10Hz to 100 Hz): <3000
- x. SMPS (Switch Mode Power Supply)
- xi. Overload Protection: Current limited, thermal overload

- xii. Front Panel Controls: ON/OFF switch, volume control, fuse or circuit breaker.
- xiii. (Maintainable from front of unit)
- xiv. Front Panel Indications: LED ON/OFF indicator lamp
- xv. Listed for Protective Signaling Service
- xvi. Supervised in accordance with NFPA 72
- xvii. Rack mountable

5.3 Voice Alarm (VA) Controller/Message Manager/ Weekly Timer

Minimum Specification

- i. Programable alarms
- ii. Storage Capacity Min. 1 GB
- iii. Remote Mic
- iv. Interface function with PC using the USB Terminal
- v. Record Function
- vi. Auto Play
- vii. Data preservation time: 7 days and more
- viii. Monitor
- ix. 3 modes of voice alarm
- x. Memory function even in case of power off
- xi. Real time diagnosis, Alarms and prompt maintenance
- xii. Voice messages via intercom
- xiii. Programming using a PC
- xiv. Back-up power

5.4 Paging Desk Microphone

Minimum Specification

The microphone stations shall include a microphone, handheld, handset or gooseneck mounted type. Each microphone station should have buttons for zone group selection to activate that microphone station for announcements into pre-programmed zones. LEDs shall indicate ready or busy respectively.

Paging capacity includes individual zone, group zone and all zone announcements.

- i. 16 switch buttons for paging zone selection
- ii. Zone in-use indicator
- iii. Emergency switch
- iv. Press-to-talk button
- v. Gooseneck microphone unit
- vi. Multi-function key
- vii. Polar pattern Cardioids
- viii. Rated Sensitivity -35dB
- ix. Frequency Response (60Hz-20 KHz)
- x. Stand Model
- xi. Capability to expand the buttons

5.5 Fireman's Microphone

Minimum Specification

The fireman's microphone of the system shall be equipped with an emergency key, permitting it to be used as a remote microphone for emergency broadcast. Zone selection and microphone announcement can have to be made at the time of emergency broadcast.

- xii. Type: Dynamic
- xiii. Frequency: 10Hz – 10kHz
- xiv. Sensitivity: -56 dBV/Pa
- xv. Impedance: 600 Ohms
- xvi. Connector Type: 3-pin XLR connector
- xvii. Audio output: 0dB, transformer- balanced
- xviii. S/N Ratio: 55dB or more
- xix. Microphone: Unidirectional dynamic microphone with key
- xx. Operation: Emergency key, Function keys, CPU switch, Preset switch
- xxi. Indication: Status indicators. Power indicator, Failure indicator, CPU indicator, Selection indicators, Microphone indicator
- xxii. Cable length: 1m Minimum

5.6 5KVA Online UPS (Number format missing)

Minimum Specification

- i. Capacity - 5kVA (Online)
- ii. Input Voltage - 230 ± 10 V
- iii. Output Voltage - 230 ± 10 V
- iv. Full-load Efficiency - ≥ 90 %
- v. Frequency - 50-60 Hz
- vi. Power generator compatible
- vii. Typical battery backup time - 30 minutes for full load
- viii. Power failures, Battery discharge, Poor battery, abnormal UPS behaviors shall alarm through Audible Alarms and Lighting (LEDs)
- ix. 1-year warranty

5.7 Ceiling mounted speakers of 6W (max)

Minimum Specification

The ceiling speaker shall be Ceiling Recessed/ surface mount type. It shall come with matching transform and spring catch for easy installation. The ceiling speaker shall comply with the following specification.

- i. Should be fire speakers
- ii. Sound Pressure Level (SPL): 90dB/wm
- iii. Driver Size (dual-cone)

- iv. Input voltage: 70V and 100V
- v. Speaker impedance: 1.7 K Ω to 13K Ω
- vi. Speaker wattage @ 100V: 6W
- vii. Comply with EMC standard
- viii. Frequency response 100Hz - 20,000 Hz
- ix. 6W/3W/1.5W power tapings
- x. Speaker shall be of 150mm dia. (approx.)
- xi. Matched with the ceiling color
- xii. Included Accessories: Metal screws for attaching speaker, driver and transformer
- xiii. 1-year warranty

5.8 Volume Controller Fail Safe 6W -120W

Minimum Specification

- i. Power-save or failsafe versions
- ii. Rated input 12W-120W
- iii. Should be fire speakers
- iv. Matched with the wall color
- v. 1-year warranty

5.9 4Core 2.5 mm2 Fire resistance cable (for VC cabling)

Minimum Specification

- i. 2.5mm 4 core
- ii. 2 Hour fire resistant

5.10 2Core 1mm2 Fire resistance cable (for Speaker cabling)

Minimum Specification

- i. 1.0mm 2 core
- ii. 2 Hour fire resistant

6 SPECIFICATIONS FOR AUDIO VIDEO SYSTEM – AUDITORIUM, CONFERENCE HALL AND MEETING ROOMS

6.1 General Specifications

The Audio-Visual (AV) system shall be designed to provide seamless and high-quality audio and visual experiences for various applications. The system should support multiple input sources, including but not limited to HDMI, VGA, and audio connectors, allowing for easy integration with different devices and content playback. It should have the capability to distribute audio and video signals to multiple display screens and speakers throughout the designated areas. The AV system should offer intuitive and user-friendly control interfaces, enabling efficient management and operation. Furthermore, it should be designed to accommodate future expansion and upgrades, ensuring long-term scalability and compatibility with emerging technologies. The system shall comply with industry standards and best practices for audio and visual performance, guaranteeing optimal clarity, resolution, and immersive sound quality. Overall, the AV system aims to deliver a reliable and immersive multimedia experience for enhanced communication, collaboration, and entertainment purposes.

6.2 Speaker cable

Item	Specification
Type	Oxygen Free Copper
Conductor	Bare copper conductors
Features	Outer and inner PVC jacket
Arrangement	2 Conductor 16 AWG
Color	Orange
Warranty	1 Year

6.3 Wall Speaker

Item	Specification
Enclosure	Bass reflex type
Power	As specified in drawings
Tap Input	3
Equalizer	N/A
Frequency Response (-10dB)	130-18KHz
Mounting	All standard Mounting accessories
Warranty	1 Year

6.4 Mix Amplifier

Item	Specification
Amplification System	Class D
Output	120W
Impedance	8 Ohms/ 4 Ohms
Input	2Mic/ AUX
Frequency Response	20 - 20,000 Hz (± 1 dB)
Total Harmonic Distortion	Please Specify
S/N Ratio	100 dB
Dimension and rate	Please Specify
Warranty	1 Year

6.5 Handheld Microphone

Item	Specification
Wireless Handheld Microphone and UHF Handheld Transmitter	Cardioid dynamic microphone
	Noiseless on/off switch
	Powered by a single dry or rechargeable AA size battery
	Long battery life (14 hours with lithium batteries, 6 hours with single AA
	size dry battery, 8 hours with optional high performance rechargeable battery) for low operating cost
	Automatic frequency setup function
Audio output:	1 x XLR sockets balanced
	1 x TS 1/4" (6.3mm) jack sockets unbalanced
Audio Bandwidth:	20 Hz to 20 kHz
Simultaneous channels:	8
Radio Range (Line of Sight):	75m
Modulation	FM
Power Supply	220~240V AC 50/60Hz

Warranty	1 Year
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6.6 Clip on Microphone

Item	Specification
Clip on Mic	Cardioid
Frequency Response	60 ~ 15,000 Hz
Connector	Mini XLR /3.5 mini jack
Sensitivity	-60dB* (1mV)*0dB=1V/μbar
Body pack transmitter	470~960 MHz
	40Hz~18KHz
	Mini XLR /3.5 mini jack
	Power On/Off, Channel, Mute
	Powered by a single dry or rechargeable AA size battery
	Long battery life (14 hours with lithium batteries, 6 hours with
	single AA size dry battery, 8 hours with optional high performance rechargeable battery) for low operating cost
	Channel, Battery Status, Power On/Off, Mute
UHF Handheld Transmitter	Automatic frequency setup function
Audio output:	1 x XLR sockets balanced
	1 x TS 1/4" (6.3mm) jack sockets unbalanced
Audio Bandwidth:	20 Hz to 20 kHz
Simultaneous channels:	8
Radio Range (Line of Sight):	75m
Modulation	FM
Power Supply	220~240V AC 50/60Hz
Warranty	1 Year

6.7 XGA Multimedia Projector

Item	Specification
Resolution	(1920x1200),
Brightness (ANSI Lumens)	Laser light source for high brightness (7000 lumens)
Contrast (with Dynamic Contrast Ratio)	20000: 1
Lamp Hour	1500hrs / 3500hrs (Normal/Eco)
Lens Shift	Yes
Optical Zoom	Yes
Screen Size	30" - 300"
Input	HDMI/VGA/S-Video /Audio-in (3.5mm) /USB Type A /Wire Remote in
Output	Audio-out (3.5mm) /Wire Remote out
Network connectivity	LAN(CAT6)
Mounting method	Ceiling
Warranty	1 Year

6.8 HDMI/VGA/AUDIO Patch Panel

Item	Specification
Input	1 HDMI, 1 VGA, 1 unbalanced stereo 3.5mm mini jack
Output	1 HD BaseT, 1 unbalanced stereo 3.5mm mini jack.
Transmission distance	130m(@1080p)
Warranty	1 Year

6.9 HDMI Cables

Item	Specification
Max resolution	4k
HDMI Compliance	HDR, HDCP 2.2, EDID
Connector and cable	3 Screened cables with 24K gold-plated K-Lock connector
Warranty	1 Year

6.10 Smart Board

Item	Specification
Type	Wall-embedded fixed interactive display
Key Features	4K ultra-high-definition display, multitouch interactivity, native integration with Microsoft Teams, wireless projection, collaboration tools, and inking capabilities.
Mounting	Flush-mounted to the wall with an in-wall enclosure for a clean, seamless look
Connectivity	Network and power from a pre-wired provision at the location.
Warranty	1 Year

6.11 Ceiling Array Microphone with Speaker

6.11.1 General Description

The ceiling-mounted microphone system shall be a networked, beamforming array microphone capable of intelligent coverage and integration with audio conferencing systems. The unit shall support ceiling or tile-mounting and must be PoE+ powered. It shall feature integrated DSP for automatic mixing, noise reduction, and echo cancellation. An integrated loudspeaker output is preferred for local sound reinforcement or conferencing feedback.

6.11.2 Technical Specifications

Microphone Array

- Type: Beamforming ceiling array microphone
- Microphone Coverage:
 - Adjustable coverage areas (minimum 8 independent steerable coverage zones)

- Intelligently auto-adjusting pickup based on talker location
- Polar Pattern: Dynamic beamforming with automatic gain control
- Frequency Response: 100 Hz to 16 kHz or better
- Signal-to-Noise Ratio: ≥ 70 dB
- A/D Conversion: 24-bit
- Audio Latency: ≤ 10 ms end-to-end
- Maximum SPL: ≥ 115 dB SPL

Integrated DSP

- Functions: Automatic gain control, acoustic echo cancellation (AEC), noise reduction, and automatic mixing
- Number of Outputs: Minimum 8 separate Dante audio outputs (or AES67 compliant)
- Control Protocols: Support for control via standard network protocols (e.g., Dante, AES67, and third-party control APIs)

Speaker Output

- Integrated speaker output or provision for external speaker integration
- Frequency Response: 120 Hz to 15 kHz or better
- Power: Capable of supporting conferencing audio feedback

Connectivity & Integration

- Network Interface: Gigabit Ethernet (RJ45), supporting PoE+ (IEEE 802.3at)
- Audio Transport: Dante / AES67 compliant
- Control Interface: Web-based UI and compatibility with third-party control systems (e.g., Crestron, AMX)
- Device Discovery: Auto-discovery on the network for simple integration

Mounting & Form Factor

- Mounting Options: Ceiling tile grid, hard ceiling mount, or suspension mount
- Form Factor: Low-profile, aesthetic design suitable for boardrooms and meeting rooms
- Color: White or paintable to match ceiling

Certifications & Compliance

- Compliance: CE, FCC, RoHS
- Environmental: Operating temperature 0°C to +40°C
- Audio Networking: AES67 and Dante compliant

Accessories (Include where needed)

- Mounting hardware for standard ceiling tile (600x600 mm or 2'x2')
- Cable kit for PoE+ and Dante network connectio

7 COLD ROOM MONITORING SYSTEM

7.1 CRMS System General Requirement

This specification outlines the design of a comprehensive Cold Room Monitoring System for a cold chain facility consisting of:

- 3 Cold Rooms (each with a WICR sensor)
- 2 Freezer Rooms (each with a WIFR sensor)
- 6 Small Freezers located inside a shared monitored space

The system shall ensure precise monitoring and alarm generation for all rooms and freezer units, ensuring product safety, compliance with storage standards, and energy efficiency.

7.2 System Architecture:

7.2.1 Sensors:

- WICRS: Wall Internal Cold Room Temperature Sensors
- WIFRS: Wall Internal Freezer Room Temperature Sensors
- Digital Door Contacts (for access monitoring)
- Humidity Sensors (for cold rooms)
- Toxic Gas Detectors: NH₃, CO₂, R134a/R404a refrigerants, and O₂ sensors

7.2.2 Controllers:

- One centralized BMS Controller/Automation Server (e.g., LOYTEC LINX, Schneider or Tridium JACE)
- Local I/O Modules (if necessary, L-IOB or equivalent)

7.2.3 Communication:

- BACnet/IP or Modbus TCP/IP

7.2.4 User Interface:

- Web-based dashboard with trend logs, alarm management, and real-time display of all rooms
- Dedicated workstation with modern GUI (HTML5-based, user-friendly interface)

7.2.5 Data Logging & Alarms:

- 24/7 data logging
- High/low temperature, gas concentration, and door-open duration alarms
- SMS/Email alerting (optional)

7.2.6 Power Backup:

- All sensors and controllers shall be powered through a UPS/Battery Backup

7.3 Monitoring Requirements:

Location	Temperature Range	Alarm Limits	Logging Interval	Sensor Type	Notes
Cold Room 1	+2 to +8 °C	High: +8.5°C, Low: +1.5°C	5 minutes	WICR + Door Contact	Mid-wall mounting
Cold Room 2	+2 to +8 °C	High: +8.5°C, Low: +1.5°C	5 minutes	WICR + Door Contact	Mid-wall mounting
Cold Room 3	+2 to +8 °C	High: +8.5°C, Low: +1.5°C	5 minutes	WICR + Door Contact	Mid-wall mounting
Freezer Room 1	-18 to -22 °C	High: -17°C, Low: -23°C	5 minutes	WIFR + Door Contact	Consider defrost cycle impact
Freezer Room 2	-18 to -22 °C	High: -17°C, Low: -23°C	5 minutes	WIFR + Door Contact	Consider defrost cycle impact
Small Freezer 1-6	-18 to -22 °C	High: -17°C, Low: -23°C	5 minutes	Compact Digital Temp Sensor	Installed inside each unit
Refrigeration Plant Room	-	See gas specs below	1 minute	Toxic Gas Detectors	Ammonia, CO ₂ , R404a/R134a, O ₂

7.4 Detailed Points Schedule:

Point Name	Type	Description	Signal Type	Logging	Alarm	Notes
CR1_Temp	AI	Cold Room 1 Temperature	Analog	Yes	Yes	From WICR
CR1_Door_Status	DI	Door Contact Status (Open/Close)	Digital	Yes	Yes	From WICR Door
CR2_Temp	AI	Cold Room 2 Temperature	Analog	Yes	Yes	From WICR
CR2_Door_Status	DI	Door Contact Status	Digital	Yes	Yes	From WICR Door
CR3_Temp	AI	Cold Room 3 Temperature	Analog	Yes	Yes	From WICR

CR3_Door_Status	DI	Door Contact Status	Digital	Yes	Yes	From WICR Door
FR1_Temp	AI	Freezer Room 1 Temperature	Analog	Yes	Yes	From WIFR
FR1_Door_Status	DI	Door Contact Status	Digital	Yes	Yes	From WICR Door
FR2_Temp	AI	Freezer Room 2 Temperature	Analog	Yes	Yes	From WIFR
FR2_Door_Status	DI	Door Contact Status	Digital	Yes	Yes	From WICR Door
SF1_Temp to SF6_Temp	AI (x6)	Small Freezers 1 to 6 Temperature Sensors	Analog	Yes	Yes	Compact integrated digital sensors
Room_Humidity (Optional)	AI	Humidity in any Cold Room	Analog	Yes	Yes	If humidity monitoring is needed
Gas_NH3_Level	Aix2	Ammonia Gas Level	Analog	Yes	Yes	In compressor /refrigeration room
Gas_CO2_Level	Aix2	CO ₂ Gas Level	Analog	Yes	Yes	Mounted low on wall
Gas_R404a_Level	Aix2	Synthetic Refrigerant Leak Detection	Analog	Yes	Yes	Optional based on refrigerant
O2_Level	AI	Oxygen Level Monitoring	Analog	Yes	Yes	General area monitoring

7.5 DDC Panel Specification:

7.5.1 Enclosure:

- Wall-mounted, IP54-rated sheet metal enclosure with internal mounting plate
- Minimum size: 600mm x 800mm x 250mm (adjust based on I/O count)

7.5.2 Components:

- DDC Controller with sufficient analog and digital inputs for all sensors
- BACnet/IP or Modbus TCP communication support
- DIN rail mounted terminal blocks, fuses, power supplies (24VDC)
- Isolated relays (if used for control output)
- Panel-mounted display (optional)

7.5.3 Wiring:

- All sensors hardwired to the panel

- Sensor cabling: Shielded twisted pair, routed in separate conduits from power cables

7.5.4 Integration:

- Provide Ethernet port for BMS integration
- Expose all relevant points (temperature, gas levels, door status, alarms) over BACnet/IP or Modbus TCP

7.6 Integration Requirements:

- All sensors must be calibrated and support BACnet or Modbus RTU (with gateway if needed).
- Sensors to be installed as per ASHRAE and EN 378 standards for cold storage and gas detection.
- Supervisor/BMS to maintain logs for minimum 12 months.
- Alerts to be routed to facility manager with timestamp and room ID.

7.7 Workstation and GUI:

- Industrial-grade or commercial workstation PC with SSD, minimum 16GB RAM, and dual monitor support
- Operating System: Windows 10/11 or Linux
- GUI Platform: HTML5-based interface (LOYTEC, Niagara, or custom SCADA)
- Features:
 - Real-time temperature and gas level display
 - Floorplan with room indicators and color-coded alerts
 - Historical trend graphs for temperature, gas, and door status
 - User login levels and access control
 - Alarm notification log with timestamps and acknowledgment

7.8 Commissioning & Handover:

- Perform full I/O testing with calibrated reference meter
- Validate logging intervals and alarm setpoints
- Test gas detectors with test gases or calibration kits
- Provide training and system manual to end users
- Submit As-Built Drawings, Point Schedules, and Configuration Backups

6. TECHNICAL SPECIFICATION OF DIESEL GENERATORS

Diesel Generators

1. Preliminaries

This Specification shall be read in conjunction with the Preliminaries Clauses for the Engineering services.

2. Scope of Work

Select based on Electrical Load Calculations for critical loads such as cold rooms, freezers and fire pump, lifts and emergency lights back up power by prime rated state of art diesel Generators, Manufacture, works testing, supply, delivery to site, erection, connecting up, site testing and commissioning of the diesel generator installation, in accordance with this Specification, BS 4999, BS 5000 and BS 5514, the IEE Wiring Regulations and the associated drawings. Equipment and systems shall conform to the requirements of DISC PD2000-1 published by BSI.

- All materials and equipment shall be new.

All equipment normally guaranteed for a time beyond the termination date of the defects liability period for this contract shall be held to remain under guarantee for the maximum period.

- General Requirement of The Diesel generating Set

The diesel generator set shall be of the "package" type, complete with all accessories and mounted on fabricated steel under frame by means of oil-resistant mounting, of shear compression type. The base frame shall also carry the radiator if a set mounted radiator is specified. The alternator shall be close coupled through a flexi disc coupling bolted directly to the engine flywheel. High tensile bolts shall be used.

This assembly shall then be bolted down to a concrete plinth through oil resistant anti-vibration mountings of the adjustable level, bonded rubber type.

All piping, conduits and cables connected with the generator shall be provided with flexible coupling, or below, as necessary to prevent transmission of the vibration.

The set shall be suitable for continuous operation and be capable of supplying the loads specified. The set shall be capable of both single operation and operating in parallel with other generating sets and be capable of supplying the electrical loads as a single unit and underload sharing operation as specified.

The set shall be transportable and suitable for satisfactory operation under the climatic and location conditions as specified.

3. Application of the Diesel Generating Set

The diesel generating set shall be used as a 'mains failure' set with automatic start-up after preset

time period or when monitored mains voltage falls below a selected value.

The set shall be under 'electric start' control. The method for initiating the start-up procedure shall be as specified.

4. Electrical Load Requirement

The generator shall have a duty output rating as shown on the drawings and at 0.8 power factor lagging, 433 volts, three-phase, 4-wire and 50 Hz. at 1500 rpm. Standard range of generator units with duty output rating within plus or minus 2.5% of the specified rating maybe offered. The generator must be appropriately de-rated for the ambient conditions of 40°C and 90% RH, at 2000 m attitude.

The generator shall exhibit the following characteristics at load power factor of 0.8 lagging.

- Steady state, load change 0 - 100% F.L.
 - Voltage - +1%
 - Frequency - +0.5%
- One Step load change of 60% from no load.
 - Voltage - the initial voltage transient shall be limited to +15% of rated voltage, recovering to within +3% of rated voltage in less than 0.2 sec.
 - Frequency - +6% to +8% returning to steady state within 0.5 seconds
 - Unbalance - With a 50% out of balance load the voltage regulation should be within +6%.
 - Short circuit - The generator shall be able to maintain a 3-phase short circuit current of approximately 3 times rated value for 5 seconds.
 - The generator should generate a waveform with deviations from a sine wave not exceeding 1.5% on open circuit and 4% on balanced load conditions as defined in B.S.5000 Part 99.

5. Diesel Engine

- General Requirement

The engine shall comprise a multi-cylinder water cooled, direct injection, two(2) or four (4)stroke diesel engine, vee-form, heavy duty, compression ignition type in compliance with BS5514 or ISO 3406, BS 1649, BS 3926, BS 4675 & BS 4959. supplied with all auxiliaries necessary for operation including, where applicable, turbo-charging and charge air cooling equipment.

Construction shall facilitate on-site maintenance and repairs, including a barring facility if

appropriate, and access to and removal of pistons and connecting rods. The engine/a.c generator unit shall be mounted on a common, rigid bedplate supported on spring-type anti-vibration mountings. Means for lifting and moving the set into position shall be provided.

The engine shall be direct fuel injected and shall be naturally aspirated, or the engine shall be direct fuel injected in conjunction with turbo charging.

The fuel consumption at the rated load under defined ambient conditions shall be as specified or as otherwise approved.

The engine shall incorporate the following:

- tachometers
- integrating hour run recorder
- air inlet filter
- Water temperature gauge
- Over-speed trip and alarm, high water temperature trip and alarm
- low oil pressure shut down protection and alarm
- Guards on all exposed moving parts
- 24 volts alternator
 - Engine Speed

The maximum nominal operating speed of the engine shall be 1500 RPM, with the nominal generator output frequency of 50HZ.

The engine speed governing system shall be of the electronic type giving regulation complying to B.S.5514: Part 4, Class "A1" to meet the tolerance values specified. The governor shall have provision for varying the speed drop from 0 to 4.5%.

Means of manual adjustment of engine speed to 5% from the nominal speed under all specified load conditions shall be provided at the control panel by means of a hand operated fine speed control.

An engine over speed prevention device shall be incorporated in the speed control system in accordance with BS 5514: Part 6 (ISO 3046/6).

- Engine Rating

The engine shall be capable of continuous operation as defined in BS 5514: Part 1. The rating shall include both full load and 110% full load for a period of one hour in any consecutive 12 hour period.

- Engine Lubrication

A complete engine lubrication system shall be provided, including a large capacity sump incorporated within the baseplate. The sump shall be fitted with oil pumps with filters on the suction and full flow duplicate filters on the delivery sides. A bypass pressure relief valve shall be fitted in the pump delivery.

The lubrication system shall provide automatic continuous lubrication of all moving parts without manual intervention. Ancillary equipment shall include:

- Oil cooler
- Level dipstick
- Filler cap
- Crankcase breather pipe or outlet
- Manual lubrication facility for priming
- Drainpipe to drain sump, with easy access in draining operations.
- Lubricating oil pressure gauge.
- Low oil pressure shutdown protection switches and alarm

The capacity of the sump together with the type, grade and consumption rate of the lubricating oil shall be as specified or as otherwise approved.

A drip tray of 2mm galvanized sheet steel with minimum 12mm high sides shall be provided where drips are likely to occur.

- Engine Water Cooling System

Coolant ducts shall be incorporated within the cylinder heads. Cooling fluid shall be circulated by means of a pump mounted on the engine. A thermostatically controlled valve shall be provided in the cooling system to assist rapid heating up of the water in the engine jacket when starting from cold, and to provide temperature control when the engine is running. Filters shall be provided in the coolant circulating system.

The cooling system shall comprise a closed circuit, engine mounted radiator with a double belt driven integral fan. The radiator fan shall be directly driven from the engine, and shall be sized to accommodate resistance of ductwork, louvers and attenuators forming the installation.

- Generator Room / Radiator Cooling

The Sub-contractor shall provide details of radiant heat output from the engine, exhaust system and generator.

Engine mounted radiators shall be connected to fire-protected air ducts or wall mounted louvers

by means of a fire-retardant flexible connection. Ductwork shall be constructed in accordance with DW 142.

6. Engine Starting

- General

The engine starting system shall be capable of starting and running the engine at a steady cranking speed appropriate to the particular engine requirements for satisfactory ignition.

The engine shall be capable of cold starting and shall start within 10 seconds automatically upon public main supply failure.

A label "DANGER - KEEP CLEAR OF THIS SET.IT IS REMOTELY CONTROLLED ANDMAY START AT ANY TIME" shall be clearly visible and provided in suitable location in the generator set room.

- Electric Motor Starting

The engine shall be started by means of 24V DC electric axial type starter motor(s) mounted on the engine flywheel housing. Where two motors are utilized for starting, each motor shall be capable of providing the required starting duty at the lowest ambient temperature specified.

The starter motors shall be mechanically and electrically disconnected when the engine fires or when the starting sequence is de-energized.

The electric start system shall be capable of being operated from the main control panel and/or any other position as specified.

Batteries shall be 24 volts heavy duty lead-acid or nickel-cadmium type as indicated in the Bill of Quantities/drawings, with ample capacity for six (6) successive starts or attempts of 6 secs with a 15 sec rest period.

Each start is assumed to begin with 1sec at locked rotor current followed by 5sec at cranking current. The battery shall be sized to limit the end voltage to 1 volt per cell for nickel cadmium and 1.65 volts for lead acid or a minimum of 70% of system voltage at an ambient temperature of 35 deg F.

Terminals and bare connections of batteries shall be suitably covered and protected against accidental shorting by tools.

- Starter Batteries

Starter batteries shall be of the type and capacity specified. The batteries shall be contained within a purpose made corrosion-resistant frame with timber cover located close to the engine. Leads between batteries and engine shall be protected against physical damage.

Battery charging equipment shall be of the constant potential type, with monitoring instrumentation type as specified, and shall be automatically disconnected during engine starting.

7. Fuel Storage

A fuel oil daily service tank shall be provided by the contractor and shall be either set mounted or free-standing with fixings, as specified.

The capacity of the service tank shall be selected for adequate capacity to operate generator 8hr at full load. The fuel tanks shall be manufactured and installed to comply with the requirements of BS 799: Part5.

The day tanks shall feed the generator set by gravity and shall be installed elevated on angle iron supports by at least 300mm above the fuel inlet of the Engine.

The service tank shall be rectangular and manufactured from minimum 3 mm thick grade CR4carbon steel plates with welded seams and suitably stiffened internally. Galvanized steel shall not be used. All welding shall comply with the requirements of BS5135. The inside and outside to be painted with oil-resistant primer and externally finished with oil resistant paintwork.

The tanks shall be supplied complete with all necessary pipework, valves, connections, and shall be clearly marked with the type of fuel oil to be used.

The tanks shall incorporate:

- 50mm dia fill opening and filler pipe extension
- Oil strainer on filler pipe
- Filler cap
- 50mm dia goose-neck vent pipe with S.S. Mesh 10 wire gauge covered opening
- Dial-type contents gauge (graduated in litres and gallons)
- 25mm dia screwed socket for fuel supply to generator set c/w gate valve and strainer filter
- 25mm dia connections for engine leak-off return pipe
- 20mm dia lockable drain valve and hose connection
- Float switch for overfill alarm
- Float switch for low-level alarm.
- 300 x 300 inspection opening hinged cover
- 1 no. M10 bolt for earthing terminal
- 50mm dia screwed socket for fuel overflow (to be plugged if not used)

Audio visual alarm provisions shall be made on the main control panel.

A hand operated fuel transfer pump of the self-priming type shall be supplied complete with flexible hose and installed by the Contractor in the position specified. The hand pump should have a capacity of 20 times the rate of fuel consumption of the engine.

The Contractor shall supply and install all necessary fire protection systems as specified.

- Day Tank

The Contractor shall design, install and commission a 1000 litres (Day) fuel storage tank complete with fuel pumping system as the fuel room as indicated in the drawing. The storage fuel tank shall be fitted with a glass fuel gauge (glass gauge with permanent indicative marking) complete with guard to indicate the level of fuel in the tank. Six (6) per cent of space shall be allowed for fuel heat expansion etc. Vent, filler and strain plug shall be provided. A suitable explosion proof electric fuel pump, explosion-proof "ON" "OFF" switch, and steel piping shall be permanently attached on the day (storage) tank and sufficient length of flexible hose fitted to the fuel pump shall also be supplied to enable replenishment of the day (storage) tank from fuel oil drums. Another semi-rotary hand pump with sufficient length of flexible hose to be supplied loose for emergency use. Drain valve outlet and inlet valves etc. shall be provided. The Contractor shall manufacture the day tank to suit the size of the generator set room as indicated on the drawing. The tank shall be manufactured according to BS 799 Part 5, Maldivian National Code of Practice and comply with local authorities requirements and are fabricated from good commercial steel plates of at least 5-mm thickness, end dished and flanged. Electrically welded throughout and spatter removed. Wiring for fuel pump shall be taken from emergency standby generator source and shall be MICC cable installation complied with IEE: Wiring Regulations.

- Diesel Fuel Pipes, Fuel Valves, Fuel Strainers

Low carbon stainless steel pipe shall be Schedule 80 black to ASTM A53 while fitting shall be cast bronze to ASME B16 or wrought copper and bronze to ASTM B16. Welded joints shall be to ANSI B31.

Flanges and unions steel pipes shall be welded.

All pipelines shall follow the routes as shown in the drawings. All tie-in dimensions shall be field checked by the contractor before installation.

All fuel pipelines shall be laid with a fall of at least 1 in 200 in the direction of the fuel flow towards valve pits.

Any change in pipeline direction shall be accomplished by the use of fittings for standard angles or trimmed fittings for angles other than standard.

Angle change between 90-degree to 45-degree, trimmed 90-degree elbow shall be used.

Angle changed between 45-degree to 22.5-degree, trimmed 45-degree elbow shall be used.

Angle changed less than 22.5-degree end of pipe shall be cut at a proper angle.

8. A.C. Generator

The A.C. generator shall be of the salient pole, self-exciting, and brushless type and shall be short circuit proof.

The generator shall be continuously rated in accordance with BS 5000: Part 99 and shall be capable of providing 110% of full load for one hour in any twelve-hour period.

Insulation to windings shall be rated Class 'F' as a minimum standard. Temperature monitoring of the stator windings shall be provided.

The generator shall be capable of developing the rated output during the load duty cycle over the ambient temperature range specified.

Enclosure class of the generator shall conform to the ambient conditions specified and as a minimum be screen protected and drip proof to IP 22.

The generator shall be self-cooled by means of an integral shaft mounted fan over the ambient air temperature range specified.

When required to operate in parallel with other diesel generators or A.C. supplies, the generator should achieve the necessary stability of operation and load sharing necessary for satisfactory operation.

Electric heater strips on the stator shall come on when the generator is not operational to prevent condensation.

- Generator Regulation

The automatic voltage regulation shall be capable of maintaining the limits on phase voltage within the tolerances specified. The voltage limits and recovery times shall be held over the load duty cycles specified. A voltage trimmer shall be provided on the AVR for fine adjustment.

Regulator components shall be contained within an enclosure mounted on the generator, the enclosure shall be isolated from any vibration forces transmitted from the generator.

The Contractor shall record the values of short circuit current available at the machine terminals, in the Tender Data Sheets.

Where diesel generating sets are to operate in parallel, the a.c. generator regulation characteristics shall be designed to facilitate such operation, including provision for manual adjustment of the characteristic on site.

The Contractor shall supply all ancillary electrical/ electronic equipment associated with the operation of the voltage regulator, for both single and parallel operation of generators.

Where links are necessary to remote switchboards and/or control panel, the Contractor shall supply all necessary terminations in his equipment.

The generator output waveform shall comply with the requirements of BS 4999: Part 40, with respect to harmonic content.

- Generator Protection

The generator shall be protected against all types of excess current that will damage the generator electrical system.

The Contractor shall provide all auxiliary equipment necessary for monitoring the electrical parameters utilized in the protection systems.

- Generator Control

General Requirement

The Contractor shall provide all equipment necessary for the starting/control/shut-down procedures for the diesel generator system specified.

- Radio Interference Suppression

The generator/regulator system shall be equipped to comply with the requirements of BS 800, BS 1597, in respect to limits of radio interference.

- Control Panel Location

The generator control panel shall be free-standing, for location at a position remote from the generating set. The Contractor shall submit full dimensions of the control panel in the Tender Data Sheets.

The engine control panel shall be set-mounted.

- Control Panel Construction

The control panel shall be manufactured from best quality mild steel plate of 2mm minimum thickness and formed in a folded and welded construction. Prior to final painting, the panel shall be suitably treated against corrosion. Back plates shall be removable and secured by bolts and shake-proof washers. Doors shall be flush fitting and suitably braced to prevent distortion and whip. Doors shall be capable of being lifted off hinges and shall be fitted with locks.

The complete panel enclosures shall comply with IP 42 (EN 60529) as a minimum standard unless a higher standard is specified.

Paint finishes shall be in full gloss stove enamel to BS 4800 colours, unless a particular finish is specified.

Where the equipment standard finish differs from the above the Contractor shall record details of the paint finish and colour in the Tender Data Sheets.

Cables or conduit entry shall be via removable plates at the top and bottom of the panel.

Means for lifting the control panel shall be provided.

- Control Panel Equipment

All facilities provided within the control panel shall be as specified.

The control panel shall be complete with all necessary equipment and facilities to control and monitor the diesel generator under the conditions of operation specified.

Control relays shall be of the plug-in dust proof type.

Contactors shall comply with BS 5424: Part 1. Transfer switches shall comply with the requirements specified. Busbars shall be fully shrouded.

Power and control components shall be located within separate sections of the panel.

Power and control circuits shall be segregated from each other within the panel.

All wiring shall be arranged in the form of suitably supported looms and/or run in slotted PVC trunking.

Wiring shall be PVC to BS 6231, for low voltage circuits.

Wiring for control circuits shall be carried out in flexible PVC cable to BS 6500.

Wiring for high voltage circuits shall conform to the special requirements specified.

Wiring within the panel shall conform to the special requirements specified.

All wiring within the control panel shall be identified by means of coded ferrules fitted to each end of the cable; the coding shall be identified on the schematic wiring diagram.

All control panel wiring shall be terminated at suitable rail-mounted terminal boards located for easy access. Terminals shall utilize a spring clamp arrangement to prevent damage to wire ends.

Control circuit wiring shall be protected by fuses in accordance with BS 88.

A main earth terminal bar shall be fixed within the control panel and positioned to facilitate connection of external wiring.

All indicating lamps shall be of the LED type and shall be mounted on the front face of the panel.

All indicating meters shall be 96mm scale, industrial grade performance to BS 89/IEC 51.

Scales shall be chosen for ease of reading and interpolation throughout the scale range.

Where timers are utilized in the protection and control circuits, each timer shall have a readily adjustable setting range incorporated in the timer module.

All control switches shall be mounted on the front face of the panel and shall be of rotary type.

All push buttons shall be mounted on the front face of the panel.

Audible alarms shall be located on the front face of the control panel with a muting facility fitted in an adjacent position.

All switches, push buttons and indicator lamps shall be identified by means of permanently fixed labels manufactured from engraving laminate.

Alternatively, push buttons shall be permanently engraved with the appropriate legend.

The front face of the control panel shall be illuminated with easily replaceable lamps. The illumination shall be provided glare free and shall not produce reflection from the glass fronted instruments.

- Features of the Control Panel

The following are the features required for the control panel.

S Indicator lamp to show operation of engine protective device with "test" and "reset" buttons.

S Selector switch for operation on "off" "auto" "manual" and "test" positions.

S A test switch for testing of the entire system including main failure detection time delay, engine starting and automatic shutdown, with or without operation of the load changeover contactors.

S Push buttons for manual start and emergency stop *S* Lamp test push buttons *S* Alarm cancel and Reset push buttons *S* Panel and Alternator heater on/off switches

9. Metering

The switchboard shall have the following instrument:-

IDMT overload and earth fault protection relays.

- One voltmeter c/w selector switch
- One ammeter c/w selector switch
- One battery charger c/w selector switch, charging ammeter & voltmeter
- One frequency meter
- One hour-run meter
- One power factor meter

10. Protection

The generator shall be provided with the following protection devices:

- engine low lubrication oil pressure alarm and trip
- engine high water temperature alarm and trip

- over-speed/frequency trip and alarm
- Over-voltage trip and alarm
- Under-voltage trip and alarm
- Failure to start circuit, permitting 6 successive attempts before automatic lockout and alarm operation.
- Earth fault trip and alarm
- overload trip and alarm
- low battery voltage alarm
- terminals for connection of remote alarms
- battery charger failure alarm
- Main tank and day tank low fuel level alarm

11. Indication lamps

The following indicator lamps shall be provided:

- battery charger on
- low battery voltage
- battery charger failure
- low fuel level at day & bulk tank
- plant failed to start
- low oil pressure shut down warning
- high engine water temperature shut down warning
- under-speed/frequency and over-speed/frequency shut down warning
- over-current and earth fault warning
- over-voltage and under-voltage shutdown warning
- mains "available" indication
- generator set available indicator
- panel and alternator heater on indicator
- non automatic flashing indicator

12. Remote monitoring / bus interphase

The generator control system shall include dry contacts and terminals for remote monitoring. The contacts and terminals shall be centralized on a common terminal strip and appropriately labelled.

The provisions required are as follows:

- Voltage terminals c/w space for mounting of voltage and frequency transducers.
- Current terminals c/w space for mounting of current transducers. Generator main ACB/MCCB status.
- Fail to start
- Low oil pressure
- High engine water temperature
- Over-speed/frequency and under-speed/frequency trip
- Over-voltage and Under-voltage trip
- Overload/earth fault trip
- Low fuel level in day tank
- Low fuel level in bulk tank
- Charger failure
- Low battery voltage alarm

13. Interconnecting Cables

The Contractor shall supply and install all interconnecting wiring between the diesel generator set, control panels, and monitoring indication positions. All wiring shall be capable of withstanding contamination by diesel fuel, lubrication oil; and shall have type, and rating consistent with the environmental conditions experienced at the site.

Main power cables shall be of the size and type specified in the drawings and shall be provided by the Contractor.

14. Earthing

The Contractor shall supply and install the complete earthing system including all earthing tape, bars, etc, associated with the diesel generator installation.

15. Mode of Operation

- Mains Failure

The generator set shall give full automatic main failure operation so designed that the plant will start at a preset voltage variation adjustable between 10 to 30% of the nominal voltage of any one of the phases. The generator set should be fully operational within 10 seconds and be capable of accepting in one step 60% load and the remaining 40% in the next 10seconds.

The operation of the Generator Set Installation shall be such that under normal conditions, the essential loads shall be supplied via the mains contactor / MCCB / ACB by the mains supply.

The mains and emergency changeover contactor / MCCB / ACB shall be mechanically and electrically interlocked to prevent parallel operation. It shall be positively interlocked mechanically in either the normal or emergency position. The contactors shall be provided with a short time delay device to ensure a clean break between opening of one and closing of the other.

- Transient Disturbance

To guard against unnecessary operation on transient disturbances, an adjustable time delay shall be provided after which the engine start/run circuit shall be energized (0-5seconds).

- Run-Up Period

Provided the mains supply is still unavailable when the correct voltage and frequency is obtained, then the emergency load shall be transferred to the generator via the change-over. The time lag between starting of emergency set and closing of emergency contactor shall be adjustable between 0 to 5 seconds. Should the mains supply be once again available during the engine 'Run-up' period, the automatic changeover switching shall abort. However, the generator set shall run-up, ready to assume load for the present run-on period and be available during this period for essential load supply. On expiry of the run-on period the shutdown sequence shall commence.

- Mains Return

When the normal supply is restored i.e. all phase voltages return to above 90% of its rated value, the generator set shall continue to run on load for an adjustable period (normally 0-60 secs) after which the load shall automatically switch over to the mains supply. The generator set shall then commence the shutdown sequence.

- Shutdown Sequence (Run-on Period)

The shutdown sequence shall incorporate a time- delay to allow the engine to run loaded for a short period before stopping the engine (1-10 minutes). All settings must then return to the normal position for automatic operation. If the mains fails during the shutdown sequence when the generator set is running unloaded, then the generator set shall (after a predetermined period (0-5 secs) to guard against operation on transient disturbance of mains supply) take on the load.

The logic for the DG sets to start and synchronize shall be as follows.

- When the total grid fails the DG sets should start one by one on master/slave basis depending on the required load and get synchronized. The choice of master/slave selection will be done automatically depending on the loads that need to be fed.
- The DG"s shall come on automatically under the above condition and shut off automatically once the normal supply is restored.
- The DG"s shall have the provision of auto load sharing facilities and shall cut off one by

one the slave DG"s if the shared load falls below 40%. Similarly, after the master DG starts the slave DG"s shall come in when the load on the master is more than 85 %. (please note that the above percentage may be fine-tuned and might vary while placing the order.)

- In case the above logic is being achieved by PLC then the requirement of UPS etc. to be considered in the offer. A detailed write up with adequate drawings must be submitted along with the offer so that the suitability of the technically can be assessed.

16. Exhaust System

- General

The exhaust system for each engine shall form a continuous unique path from the engine to the termination position. Inspection and cleaning doors shall be provided at changes of direction and at the base of vertical stacks.

The selection, sizing and fixing on site of all sections comprising the exhaust system, including the silencers, shall be suitable for the installation specified.

Flexible, gas tight joints shall be provided between engines and the exhaust system to permit thermal expansion and to prevent vibration transmission.

The exhaust system shall be adequately supported throughout with spring hanger's where necessary or specified. Where the system is within the confines of the building and wherever else specified, appropriate thermal insulation material shall be applied to the pipework and silencers to limit C completed with embossed aluminum cladding surface temperature to 55.

A moisture trap and Drain points for the removal of condensate shall be provided at the lowest point of the exhaust system and at the base of vertical stacks complete with a draincock.

The discharge of the combustion products shall be located such as to meet the requirements of the relevant authorities. The discharge outlet shall be angled or provided with an automatic shutter to prevent ingress of rainwater.

For the Exhaust discharge, suitable soot dilution system should be Introduced in line with manufacture's recommendation or else generator exhaust needs to be taken above roof top with a stainless steel piping.

17. Engine Silencers

Silencers shall be incorporated in the exhaust system to maintain the external noise levels specified. If no noise levels are specified, the noise level should not exceed 85 dB at 1 meter from the exhaust pipe under true field conditions.

18. Room Acoustic System

Room acoustic to be provided to maintain the sound level of the room.

19. Piping - purpose made

Exhaust systems shall be fabricated from carbon steel pipe to BS 3601, with dimensions to BS 1600, for installations up to and including DN 600, welded or flanged and of standard wall thickness to provide adequate internal corrosion allowance.

Over 600mm bore the exhaust system dimensions shall be calculated in accordance with BS 4076, Specification for steel chimneys, and the installation shall be fabricated from steel plate to BS 4360, Grade 43EE.

External corrosion allowance shall be made for fully exposed systems, i.e. those uninsulated and not metal-clad.

The pressure loss through the exhaust system shall not exceed the value recommended by the manufacturer.

Expansion devices shall be located midway between anchor points firmly fixed to the building structure, positioned as specified. Anchor clamps shall be lined with foam glass (or equal) inserts to minimize heat transfer to the structure.

Expansion devices shall be low pressure rating suitable for C with pipe guides provided on corrosive atmosphere and temperature up to 520 either side of each expansion device.

Devices shall be corrugated bellows type with internal sleeves of Incoloy 825 or similar, installed with maximum 'cold draw'.

The base of any vertical section of the exhaust system shall have a tee pocket and welded-in tundish of mild steel, tapped for and provided with a 19mm carbon steel drainpipe extended to near floor level without causing obstruction to personnel or operations.

The low point of any horizontal section of the exhaust system shall similarly have a tee pocket, tundish and drainpipe splay cut at bottom or lower ends.

Before insulation all exhaust piping and brackets shall be wire-brushed clean of rust, scale, etc, and cleaned of grease and oil and painted with one full coat of silicone aluminium heat-resisting paint.

The exhaust piping shall be completely insulated with 50mm thickness mineral wool rigid sections, secured with wire ties or metal bands. Flanges shall be insulated for 75mm either side of joint faces to the same thickness as the piping. Aluminium cladding shall be 1mm thickness

embossed style.

Exhaust piping through the wall shall be sleeved, the outer pipe being provided with a split circular flange properly fixed to each side of the wall, the sleeve to be packed internally with rock wool and grouted to the wall.

20. Inlet and Discharge Louvers

Details of air resistance values and dimensions of all louvers (including acoustic louvers) shall be submitted in the Tender Data (return) Sheets.

Where necessary, louvers shall incorporate attenuation in order to achieve the noise levels specified.

External louvers shall be provided, complete with all necessary fixings and manufacturer's fixing instructions.

- General Requirement

Air intake and discharge points shall be protected from ingress of moisture and dust by framed and shaped weather louvers.

The space immediately behind or below louvers shall be 'tanked' and adequately drained to remove deposits of moisture.

Any ductwork immediately behind an intake or exhaust louver shall be properly prepared and painted on all internal surfaces with epoxy resin or bitumastic paint for a length from the louver equal to the louver height, duct length or to the next equipment item, whichever is the lesser. The bottom side of the ductwork connection shall slope downwards towards the louver.

Louvre free area shall not be less than 50% of the total area of opening and overall size shall be matched to airflow requirements of the engine.

Louvers shall be suitable for building into a structural opening, or fixing to substantial groundings.

Galvanized wire bird screens shall be fitted to the inner face of all louvers with provision made for removal for cleaning. Screens shall extend over the full face of the louver and be of 10mm mesh size. All fixing clips, screws and washers shall be hot dip spun galvanized.

Adequate size closed-ends drain gutter sections at the bottom of each louver or louver section with an outlet branch piped to the nearest gully or discharge on an adjacent roof as applicable shall be provided.

- Steel Louvers

Frame and blades shall be fabricated from galvanized mild steel sections and sheet with cut edges

repaired with cold galvanizing solution.

Galvanized steel louver assemblies shall normally be bolted together. If welding methods of assembly are used the galvanizing shall be reinstated immediately on completion of welding. Where specified galvanized steel external louvers shall be etch-primed and a painting system applied having a five-year minimum warranty against colour fade, deterioration of surface finish, peeling and flaking. Colour to BS 4800, shall be as specified.

- Aluminium Louvers

Frames and blades shall be fabricated from aluminium alloy extruded sections. Finish shall be as specified.

Aluminium alloy louver assemblies shall be inert gas shielded arc welded or bolted or riveted together.

- Acoustic Louvers

Units shall be as specified and of specialist manufacture. Performance figures for both sound reduction and air passage pressure drop shall be available.

Louvers shall have a rigid casing housing double skin blades with plain top surfaces and shaped, perforated undersides to achieve maximum attenuation. Infill material shall be odorless, non-hygroscopic, non-toxic, and non-combustible, not decompose, not support fungoid life nor attract vermin or rodent attack, packed in sealed plastic film containers.

Blades shall be positioned to provide weather protection. Acoustic performance shall be as specified. The whole assembly shall be protected against corrosion.

Reciprocating i.c. Engines - noise and vibration

- Noise Control

The specified sound pressure level to be measured 1m from the exhaust discharge shall not exceeded.

The sound pressure levels due to the combined effect of exhausts, machinery and background noises shall not exceed the values indicated at the locations specified.

The parts of the exhaust system downstream of a silencer and inside the engine room, or in ducts with other services, or in ducts with duct covers opening into occupied areas, shall have insulation at least 50mm thick covered with sheet steel of specific weight of 10-12kg/m².

The sheet steel sections shall be cut out at supports and expansion joints only and all joints shall be riveted or made with self tapping screws. The insulation shall be as for acoustic louvers.

Constant speed engines shall be fitted with two-stage exhaust noise silencers. The peak attenuation of the first stage shall be at the firing frequency of the manifold to which the exhaust

is attached, with a drop in attenuation 1 octave each side of this frequency not exceeding 5dB. It shall be as close to the manifold as possible.

The attenuating characteristic of the second stage shall be complementary to the first and shall cause the spectrum of the exhaust noise at the point of discharge to approximate to the NR specified within D}5dB over the range of frequencies emitted.

Where there is no restriction in plant space, the second stage attenuator shall be fitted not less than 10 pipe diameters from the first and shall be followed by tail pipe 10 pipe diameters long. The second stage shall be located in the engine room if the tailpipe passes through occupied spaces.

Where an exhaust system runs with less than two bends between the flexible bellows connection at the manifold and the point of exit from the plantroom, a second bellows connection, similar to the first, shall be located just before the point of exit.

21. Vibration Control

The parts of the exhaust system in the engine plant room shall be suspended from spring hangers. The spring hangers shall allow unstressed expansion of the exhaust system without significant changes in hanger loads or excessive deflections of the flexible connections.

The isolation efficiency of spring hangers at engine rotational speed (or firing frequency if this is lower) shall not be lower than:

90% when the basic support is a ground slab or retaining wall,

OR

96% when the basic support is a suspended slab, a column or part of a steel frame type structure. The isolators shall be suitable for the ambient temperature and metal contact temperature specified.

Supports for tail pipes passing through occupied spaces shall include pads or bushed washers to prevent metal to metal contact between the parts of the support fixed to the tailpipe and the parts fixed to the structure.

Supports for tail pipes passing through occupied spaces shall include vibration isolators with efficiencies of not less than 90% at the firing frequency of the manifold to which the tailpipe is connected.

The isolators shall be suitable for the ambient temperature and metal contact temperature specified.

Intervals between spring hangers shall be chosen to give adequate structural support without causing resonance of the supported length at the manifold firing frequency or the engine rotational

frequency.

Vertical sections of tail pipes shall be supported at floor slabs and be guided between as necessary to avoid resonance. Horizontal sections, where not shown otherwise, shall be run close to junctions of walls and floors.

22. Testing and Commissioning

- General Requirement

For Testing and Commissioning The diesel generator system shall be tested at the manufacturer's works and on site, in accordance with BS 5514 and IEE Regulations.

The results of the tests shall be tabulated by the Contractor on a purpose-designed form, signed by the Contractor's staff and test witness. Three typed copies shall be submitted to the Architect within seven days of completion of tests.

The Contractor shall supply all materials, apparatus, instruments and qualified personnel to carry out the testing and commissioning. Commissioning shall be deemed to include all operations required in order to correctly set the plant to work to comply with relevant specifications and Codes.

In the event that the equipment or any part thereof, fail to meet the requirements herein specified, the Contractor shall, at his own expense, rectify, replace or rebuild, any or all respective parts of the equipment until the equipment does fulfil the test and performance requirements. Equipment which has been tested on three occasions without fulfilling the offered performance shall be rejected.

The subcontractor must carry out a preliminary check and test on the systems before requesting the attendance at site of the Engineers and the representatives from client to witness the full scale testing and commissioning of the systems.

The contractor is required to make application to the Engineer giving at least seven days notice in writing when requesting acceptance tests on any portion of the works. The application must be accompanied by a complete set of records indicating all plant settings, and measurements as adjusted by the Contractor, together with the respective design values.

The testing and commissioning procedures shall include the following:

Visual check of all work for completeness

Check that all work complies with the latest Regulations, specifications, performance criteria.

Check that all equipment is safe to operate, and that overloads, safety devices and interlocks are all in working order.

Check operating sequences, function of all devices and direction of rotation.

Verification of performance under site conditions, under load and simulated "Worst case" condition.

- Testing of Electrical Works

Supply necessary meters, instruments, temporary wiring and labour to perform all required tests and adjustment of equipment and wiring installed and connected under this subcontract, including the electrical equipment supplied by others to determine proper polarity, phasing, freedom from earth faults and short circuit and the proper operation of equipment, meters, relays, etc.

The testing and commissioning procedures shall include the following:

- ✓ Insulation tests shall be made with 500V "Meggar". No cable will be accepted with an insulation resistance, including termination, of less than 50 meg-ohms.
- ✓ Test continuity and unique identification of all conductors in all cables.
- ✓ Measure resistance of main earth and test all earth continuity connections & Check polarity and phase rotation of supply.
- ✓ Di-electric test on switchboards - 3kv for 1 minute
- ✓ Primary injection tests to verify settings of current tripping devices.
- ✓ verify ratio and polarity of current transformers
- ✓ Check of clearances and creepage distances.
- ✓ Mechanical operation
- ✓ Control interlock and tripping sequence operation
- ✓

- Hydraulic Tests-fuel pipework

Pipework shall be hydraulically tested in convenient sections as the work proceeds and witnessed by a representative from the Consulting Engineer.

Pipework shall be tested to 1 1/2 times normal working pressure but not less than 1033 kPa (150 psig) and shall be applied and held for 24 hours. Pressure shall not show a drop of more than 4% in 24 hours. In the event of test failure, leaks shall be found, made good and the line retested.

Hydraulic test on pipework shall be carried out before pipe insulation work. Any item which is liable to damage at the test pressure shall be isolated in an approved manner during the test. Pipework under the test shall be fully vented.

- Testing of Fuel tanks

The storage tank shall be subjected to a pneumatic or hydraulic pressure test at the factory, prior to delivery to site, at a pressure of 0.7 bar measured at the top of the tank for not less than 6 hours.

No leakage is allowed.

The storage tank shall after it has been lowered onto the concrete base be subjected to a pneumatic test at a pressure of 0.7 bar for not less than 6 hours. No leakage shall be allowed.

Test report for the tank, associated pipes and fittings shall include the following information:-

- Name of tank owner
- Manufacturer's serial number
- Description of test
- Test conditions
- Date of test
- Results of test
- Comments
 - Generator performance test

A test of the generator set shall be carried out at the manufacturer's work. This shall comprise.

General inspection of equipment to check its compliance with specifications.

Verify lubricating oil and coolant levels and type, battery charge and electrolyte level, free movement of control linkages, removal of transit protector's and inhibitors, bleed fuel system of air, verify tightness of all connections, etc as listed in the manufacturers manual.

Measurement of cold resistance and continuity of the electrical windings.

A timed start from operation of the start push- button to acceptance of full load.

A performance load tests as follows:

Four (4) hours running at full rated load

One (1) hour at 110% F.R. Load

One (1) hour test run at 75%, 50% and 25% F.R. load.

Graphs of specific fuel consumption (lb/kw.hr) shall be provided for related tests.

Half hourly readings of exhaust temperatures, water temperature, ambient temperature, lubrication oil temp and pressure, alternator power output, voltage, frequency, and engine speed etc. shall be provided during test mentioned above.

Alternator and exciter maximum winding temperatures shall be recorded immediately after the 4-hour F.R. Load trial.

Determination of frequency and voltage regulation under the instantaneous load changeset: - No load to maximum load Full load to no load

Operation of all protective circuit and devices together with verification of the settings of relative sensors

- Site Test

On completion of installation, site tests on the generator, comprising starting, stopping, running load tests shall be carried out to prove the performance of the fuel system, cooling system, cabling, control as well as the set is not damaged en route.

A dummy load may be used in this case.

Readings of noise levels shall also be taken to prove that the specified noise criteria are achieved.

- Tools and Accessories

A Complete sets of tools and portable indicating instruments for the operation and maintenance of all the plant and equipment shall be provided, together with suitable means of identification, storage and securing.

Each unit shall be supplied complete with the following spares:

- 1 set of AVR & rotating rectifier unit 1 set outlet fuel nozzles
- 1 set of engine gaskets
- 2 sets of belts, fuel filter, air filter, water filter and lubrication oil filters

23. Works Tests

The Contractor shall inspect and test at the makers' works, during manufacture and after completion, all or any particular manufactured material, apparatus or equipment ordered by the Contractor for incorporation in the Works, in order to prove that the material, apparatus or equipment meets the requirements of this Specification and shall notify the Architect in advance of all such inspections and tests.

The Contractor shall submit to the Architect, at the time of issue, three copies of each and every order for bought in material, apparatus and equipment intended for incorporation in the Works. Each such order shall clearly state whether the item(s), which it covers, is or are subject to inspection or test before dispatch to site.

Upon completion of manufacture, or before dispatch in the case of stock items, all material, apparatus and equipment intended for incorporation in the Works shall be subjected, to the tests specified in the relevant National Standard or elsewhere in this Specification together with such additional tests as maybe required in order to prove compliance with this Specification. When no relevant British Standard exists, or the appropriate National Standard fails to specify tests, the Contractor shall submit his proposals for the tests he requires providing compliance with the Specification.

The results of each and every test carried out in accordance with the provisions of this

Specification shall be accurately and comprehensively recorded on a form of test certificate signed by the person in charge of the testing procedure and countersigned by the Contractor and four copies of every such test certificate shall be submitted to the Architect.

Every test certificate shall include, in addition to all other requirements, the date and time of the test, the ambient conditions, a fully detailed description of the test(s) carried out, the results obtained, and any relevant performance curves.

The Contractor shall be responsible for ensuring that the Architect is advised in writing whenever material, apparatus or equipment is ready for inspection or test at his own or his suppliers' premises. At least seven days notice shall be given, and due allowance shall be made for this period of notice in drawing up the programme of work.

In cases where the manufacturer or supplier of material, apparatus or equipment relies upon type tests to prove, either wholly or in part, the suitability of his product(s), then the Contractor shall arrange for triplicate copies of certificates giving the results of such type tests to be submitted to the Architect at the time the order is placed.

No material, apparatus or equipment, from whatever source, shall be dispatched to site until the Architect has had the opportunity to inspect it or has given written authorization for dispatch. No inspection or testing by the Architect nor the witnessing of satisfactory tests nor the authorizing of dispatch to site shall in any way relieve the Contractor of any of his obligations.

under this Sub-contract, nor shall it in any way limit the right of the Architect to reject such items after delivery to site if they subsequently prove to be defective or unsatisfactory or unsuitable for their intended purpose.

When the Contractor has ordered equipment from a manufacturer who, in turn, has bought-in major components from a secondary supplier, the Architect shall have the right to elect to inspect such components at the works of the secondary supplier, and the Contractor shall ensure, when placing his orders, that such rights are secured. For the purpose of this clause, inter-departmental orders within the same organization shall be treated in the same manner as orders involving separate organizations. The Architect shall have the right to waive, at his sole discretion, the requirements relating to his inspection of materials, apparatus, and equipment at the makers' works. The exercise by the Architect of this right shall not in any way relieve the Contractor of his obligation to carry out the prescribed tests and to submit test certificates.

No work shall be painted or otherwise prepared for dispatch until it has been inspected by the Architect, or inspection has been waived, and dispatch has been authorized.

When one or more of the Contractor's purchase orders covers the supply of a number of like

components or items of equipment, the Architect shall have the right to require that one item or component of each type and rating be subjected to type tests as described in the relevant National Standard. Other similar items may then be subjected only to routine tests.

- Site Test

- General

The Contractor shall carry out all necessary checks and tests to prove that the completed installations fully comply with specified requirements.

Upon completion of the electrical installation, or any substantial section thereof, the installation or that section and all of the associated electrical equipment shall be subjected to the tests specified in the relevant National Standards and in the IEE Wiring Regulations, together with such other tests as may be specified in order to prove compliance with the Specification.

All of the required checks and tests shall be carried out in accordance with a programme to be agreed with the Architect, and facilities shall be made available for the Architect to be present at all such checks and tests if he so desires.

Tests not carried out in the presence of the Architect shall not be regarded as valid for the purpose of the Contract, unless the Architect shall have authorized the Contractor to proceed with the testing process in his absence.

Every test certificate shall include, in addition to all other requirements, the date and time of the test, the ambient conditions, a fully detailed description of the test(s) carried out, the results obtained, and any relevant performance curves.

No material, apparatus, equipment, or installation shall be covered or otherwise permanently concealed from view until the Architect has had the opportunity to inspect it or given written authorization for covering to proceed.

No work shall have a final paint finish until it has been inspected by the Architect or painting has been authorized, unless the final paint finish is necessary to provide the necessary climatic protection.

No apparatus, equipment, plant, or installations will be recognized as complete until all of the specified inspections and tests have been satisfactorily carried out.

The Architect shall have the right to waive, at his sole discretion, the requirements relating to his inspection of materials, apparatus equipment and installations and the witnessing of tests thereon. The exercise by the Architect of this right shall not in any way relieve the Contractor of his obligations to carry out the prescribed tests and to submit test certificates.

The following test should be carried out in all the installations.

- ✓ Insulation resistance testing - Testing of insulation of cables and bus risers according to the British/IEE Standards to ensure the cables are adequate to prevent electrical fire and in a healthy manner. Require power isolation.
- ✓ Loop resistance test - Testing of earth loop impedance to ensure the connectivity of earthing conductors, to analyze earth fault trip settings, etc. Intermittent Power cut will be experienced, verification of Earth Fault Protection coordination.
- ✓ RCCB Testing - To check the necessary RCCBs according to IEE/IEC standards. During the test tripping will happen.
- ✓ Continuity test on bus risers Continuity test on Earthing and Bonding

The following analysis should be carried out in all the installations.

- ✓ Visual Inspection - Visually inspect the distribution paths, switch gear, selected lighting fittings, earthing network, Surge arrestors etc. Do not require power isolation. (Verification of the as built distribution system. and updates if any and establishing sectional isolation points if necessary) Cable Breaker Coordination analysis - Analyze the loading capacity of cables for installed circuit breakers according to British/IEE Standards. Do not require power isolation.
- ✓ Fault level calculation - From Main Distribution board to each floor Distribution Board
Earth Fault Setting calculation - From Main Distribution board to each floor Distribution Board

Further to the above Thermo graphic survey of the electrical system From Main Distribution board to each floor Distribution Board to be required to done.

- Cable Testing

As soon as is practicable after the completion of installation and jointing of the cables specified herein, or of any usable group of such cables, the Contractor shall carry out the tests described below, together with such other tests and measurements to prove compliance with this Specification and with the requirements of the IEE Wiring Regulations.

An insulation resistance test, carried out with a 'Megger' insulation tester or other similar type of testing instrument, to measure the insulation resistance between each conductor and the remaining conductors and between each conductor and the metallic sheath, if any, and armouring. The test voltage to be applied shall be as follows:

Low voltage cables - 500 volts

High voltage cables - not less than 1000 volts

The above tests shall be carried out both before and after any voltage tests and the insulation resistances shall not be less than the figures in BS 6346, Table 6, for all cables up to 3.3kV. The Contractor shall submit insulation resistance figures for cables above 3.3kV.

A voltage withstand test of 15 minutes duration shall be applied in accordance with the relevant British Standard, at the test voltage indicated in:

BS 5467, Table 7, of for cables with thermosetting insulation,

BS 6346, Table 5, for PVC insulated cables, or

BS 6480, Table 6, for paper insulated cables.

The Contractor shall submit proposals on the appropriate test voltage in respect of other types of cable.

Mineral insulated cables shall be subjected, on completion of installation and jointing, to a voltage test in accordance with BS 6207 Clause 8, for copper sheathed cables. The test voltage shall have the value tabulated in the appropriate Appendix and shall be applied for 30 seconds.

An earth continuity test shall be carried out to verify that the cable armouring and metal sheath, if any, have been properly bonded to earth.

Phase-rotation and phase-correspondence shall be tested to prove that the cables have been correctly connected.

- Low Voltage Switchboard Tests

Low voltage switchboards shall be thoroughly checked for correct functioning in every respect and shall be subjected to the following tests:

With all control circuits disconnected but with all isolators closed and power fuses fitted, the panels shall be subjected to a voltage test across the following points:

Phase to phase

Phase to neutral

Phase to earth

Neutral to earth

The voltage levels and test directions shall be in accordance with the relevant National Standard for the equipment provided.

This shall be followed by an insulation resistance test with an approved type of 500 V test instrument.

With all electronic components and time switches removed or isolated and with all main isolators closed and power fuses fitted, an insulation resistance of not less than 20 Mega ohms shall be

obtained between each of the following points:

Phase to phase

Phase to neutral

Phase to earth

Neutral to earth

- System and Equipment Earthing

The Contractor shall inspect and carry out tests on all the system and equipment earthing provisions in accordance with the requirements of the IEE Wiring Regulations.

The method of testing and the selection of suitable test instruments shall conform to the guidelines given in the IEE Wiring Regulations.

These tests shall be carried out on all system and equipment earthing supplied, installed and connected under this Contract.

Where an existing installation has been effectively extended in relation to the system and equipment earthing provisions supplied under this Contract, the existing system and equipment earthing shall be inspected and tested for compliance with the IEE Wiring Regulations.

The Contractor shall inspect and re-test the system and equipment earthing provided under this Contract thirty days prior to the end of the Defects Liability Period. The Contractor shall give the Architect seven days notice of his intent to carry out these tests.

7. TECHNICAL SPECIFICATIONS OF SOLAR SYSTEM

1. Solar PV system

Solar PV Modules, Inverters and Switchgear items must bear IEEE 1548, AS 4777, UL 1741 or equal standards. General process certification such as ISO 9001 shall be used to support manufacturers' quality assurance.

I. Protection against Extreme Environment Conditions

- The System as a whole must be designed to operate within the most extreme environmental conditions that can reasonably be expected at the site over the system life.
- The following environmental design conditions shall apply.

1	Ambient Temperature	-	+ 15° C to + 40° C
2	Relative Humidity	-	10% up to 100% (rainy season)
3	Wind Speed	-	High
4	Salty / sea breeze environment	-	Extremely salty environment

II. Electrical System

The standard is 230V AC SP 50Hz, 400V AC 3P 50Hz.

III. Technical specification for solar PV module

✓ General Requirement

- Orientation of the panels should be in such a way that it always gets the maximum power.
- All PV Modules within an array shall be of same type and size and hence interchangeable.
- Only one size and model to be used.
- Each module must be clearly marked indicating Manufacturer, Model Number, Serial Number, Peak Watt Rating, Peak Current, Peak Voltage, Open Circuit Voltage and Open Circuit Current.

Module Type	:	
Module Power Output	:	
Power Tolerance	:	
Module Efficiency	:	
Cell Configuration	:	
Cell Size	:	
Maximum System Voltage	:	
Operating Temperature Range	:	
Relative Humidity	:	

Surface Maximum Load	:		
Standard Test Conditions (STC)	:		
Warranty	:		
Certification	:		
Materials	:	Glass Cover	- Anti-reflective low iron
			- Tempered glass
		Frame	-Anodized Aluminum Alloy Sheets
		Back Sheet	-Whether resistant Back film material
Modular Weight			

✓ *Module Interconnectors and Cabling*

- Module shall be provided with 4.0 mm² leads (positive and negative terminals).
- Cables lead length approximately 1,000 mm. with weatherproof connectors
- Class II rating for Inter-connecting cables and connectors (MC4 preferred).
- IP 65 Protection rating
- System Voltage max. up to 1,000 VDC.
- 20A current rating.
- Temperature up to 80° C.
- 4.0 mm² Cables.
- Snapping Locking System.
- Wiring shall be permanently shaded from UV radiation.
- The arrangement of Modules on the Structure and their Interconnections shall be designed to enhance servicing and inspection.

✓ *Junction Boxes*

- Each Module shall have a Sealed Junction Box.
- Shall be Dust Proof and Water Proof (IP 65 rating) and capable of dissipating the heat generated by internal components.
- Shall have corrosion resistant non-conductive enclosure.
- Shall have suitable cable entry points fitted with cable glands of appropriate sizes for both incoming and outgoing cables.
- Shall be fitted with appropriate rating bypass diodes.

✓ *Structured Assembly*

- The array support structure shall be fixed.
- The complete structure should withstand wind speeds of 100 km/hr or better.

- The array support frames and mounting superstructure shall be provided in several identical sections to allow for any thermal expansions and connections.

✓ *Technical Specifications for Grid Tie Inverter*

- Shall be designed specially for utility grid interconnection of PV arrays.
- Shall be capable of automatic, continuous and stable operation over the range of voltages, currents and power levels for the size and type of array used.
- Shall be compatible with local utility and shall have all disconnection parameters changeable on site through software and all relevant configuration tools shall be provided to purchaser.

✓ *Technical Specification*

Operating Temperature	:	- 20 to + 60° C
Ventilation	:	Forced or Convection
Relative Humidity	:	95% maximum
Communication	:	RS 485, Bluetooth or equal
Display	:	Any error messages, DC/AC Voltage/Current, Frequency, Cumulative Power Output kWh, Instant kW Production
Total Harmonic Distortion	:	Less than 5%
Protection	:	Input Over Voltage
		Low / High Frequency
		Short Circuit
		Under / Over Output Voltage
		Over Temperature
		DC Polarity Reversal
		Grid Input Under / Over Voltage with Auto Recovery
		Anti – islanding
		Include within Inverter DC Side DB if not Integrated into Inverter
		DC Disconnection Switch
		DC Ground Fault Current Protection by an Integrated Ground Fault Detection and Interruption Device (GFDI)
		DC Surge Arrestors
		Include within Inverter AC side DB if not integrated into Inverter
		AC Disconnection Switch
		Residual Current Device

✓ *Program setting*

- All utility compatibility settings and safety setting shall be documented and submitted to the purchaser with the System documentation.
- The Inverter shall have programmable parameters for disconnection from the utility network to ensure compatibility with network characteristics.

✓ *Synchronization*

- The Inverter shall synchronize with the utility network before the parallel connection is made.
- Automatic synchronization equipment shall be the only method of synchronization.
- The limits for the synchronization parameters for each phase are given in the local guide code.

✓ *Utility Compatibility*

- Required standards IEC 61727:2004, IEC 61003-3 or equal standards accept by the utility provider.

✓ *Line Surge Protection / Protection*

- DC System - Surge Protection devices on the inverter DC inputs.
- AC System - Surge Protection devices at the incoming point of supply / PCC.
- The Contractor shall provide and install all necessary protective devices / equipment against over lightning and Voltage Transients for the signal and power line.

✓ *PV Plant Monitoring System*

- Internet and IP address monitoring for remote access. Monitoring shall include daily kWh, Daily kWp, String Currents, Web Based Database for remote access.
- Measurement equipment linked to PV Plant Monitoring System, minimum requirement shall include
- Global Irradiance Meter, Anemometer, and Module Temperature and Ambient Temperature.

✓ *Component Warranty*

PV Modules	:	Minimum Performance warranty of 25 years on PV Modules on 80% power output.
Array Structure	:	3 years from the date of commissioning.
Inverters	:	10 years from the date of commissioning.

Electronics Supplied	:	2 years from the date of commissioning for all other PV System Components including any specific AC or DC Appliances provided under the Contract.
All Other Equipment	:	2 years from the date of commissioning.

✓ *Drawing and Contract Required*

Solar PV Module	:	Module Catalogue / Data Sheet (Highlight Model offered)
		IEC 61215 Certificate
		IEC 61701 Certificate
		PID Certificate
		Third party performance data preferred up to warranty period
Inverter	:	Data Sheet (Highlight Model offered)
		Type Test Certification required by CEB / LECO
DC Cable	:	Data Sheet / Catalogue
		Applicable SLS / IEC Standard
AC Cable	:	Data Sheet / Catalogue
		Data Sheet / Catalogue
Surge Protection Device	:	Data Sheet / Catalogue
Electrical Diagrams	:	Block Diagrams indicating schematics of System

8. TECHNICAL SPECIFICATION FOR VERTICAL TRANSPORTATION SYSTEM

8 GENERAL TECHNICAL SPECIFICATIONS FOR VERTICAL TRANSPORTATION SYSTEM (PASSENGER AND FIRE)

8.1 Introduction

The site is developing as a facility providing premises for the cold rooms which are using for the vaccine packing purposes. The site is located at the Hulhumale, Maldives. Relevant civil works are commencing at the site premises from upcoming months.

The overall building consists of 10 nos. of floors as Basement Floor, Ground Floor, 1st – 8th Floor, Roof Terrace Level and Lift Machine Room Level.

The scope of work to be carried out under this project includes but not limited to the following:

- All Civil and Architectural works from Basement Floor up to the Machine Room Level.
- Installation of building services (from Basement Floor up to the Machine Room level).

The project is consisting with 01 nos. of basement floors for car park areas, other office, auditorium & cold rooms area in ground to eighth floors and roof terrace level in 9th floor. Basically, 02 nos. passenger lifts are installed for the passenger travelling and both lifts are operated in basement to roof terrace level. 01 nos. fire lifts are installed for the fireman operation and it is operated in basement to roof terrace level.

Total floor area of the building is approximately 5,600 m² and the total height of the same is 37.05 m from ground level to roof terrace level.

The Works have to be organized accordingly to avoid any interruption disturbance to adjacent buildings.

All equipment being supplied shall be suitable for operation under tropical conditions with ambient temperature up to 36°C and relative humidity up to 90% but not both simultaneously.

Civil Works and other Building services such as Air Conditioning and Ventilation System, Building Management system, Telecommunication, acoustic insulation etc. will be executed under separate contracts. Location of the site.

8.2 Lift Installation Work

This section consists of the general rules that apply to the design, manufacture, shop testing, delivery to site, installation, commissioning, factory testing, site testing, maintenance during defects liability period and handing over the plant, equipment and services required

for the Vertical Transportation System and related work as stipulated in the specifications, drawings and the equipment list for the proposed central cold chain facility with climate - friendly designs at Hulhumale, Maldives.

8.3 Co -Ordination

The Contractor shall co-ordinate the Vertical Transportation System installation with installation work of all trades involved in the project to avoid interference with lighting fixtures, piping, ducts, etc.

8.4 Submission of Contractors

8.4.1 General

The Contractor shall make for approval by the Engineer of the following, but not be limited to those.

- Selection Data/Equipment Data
- Design analysis and calculations
- Detail and/or Shop Drawings
- Schematic & Interconnection Diagrams
- Monthly Progress Report
- Certificate of Compliance/Test Reports Certificates
- Operation and Maintenance Manuals

All the documents shall be in language of English. Selection data shall be submitted in triplicate and shall consist of engineering selection tables provided by the manufacturer for the performances and the acoustics of equipment. The Contractor shall indicate in these, the items selected and their designation for cooling equipment.

These documents in required number of copies specified should be handed over to the Engineer and Engineer required minimum **twenty-one (21)** days to check and give the approvals. Therefore, the Contractor shall consider that time period for submissions and approval process, while preparing the Schedule of Contract Work. All the submittals (technical, sample and shop drawings etc.) forms shall be signed by the Technical Manager assigned for the project, on behalf of the Contractor.

8.4.2 Shop Drawings (Working Drawings)

The contractor shall prepare and submit to the Engineer for approval **three (03)** copies of following shop drawings as a minimum. These drawings shall be submitted in sufficient time for approval to be granted prior to start installation at site.

- (i) Plans showing door opening sizes, shaft dimensions, car dimensions, location and dimensions of counter weight etc.

- (ii) Sections showings door openings, landing locations of operating panels/ car operating panel/ disabled operating panels with dimensions, fireman switch location, locations and capacity of hoisting hooks etc.
- (iii) Sections & Plans showing ladder locations, details and arrangement of car top, details and arrangement of lift pit, trap door lotions and dimensions etc.
- (iv) Structural reinforcement details, reactions loads and locations.
- (iii)General arrangement plans, layout and outline drawings of system components
- (iv)Position plans and sectional installation details.
- (v) Power and Control Wiring diagrams.
- (vi)Schematic diagrams and interconnection diagrams.

Signed and approved drawings shall not be deviated from unless a signed variation or a site instruction is issued in writing by the Engineer.

Amended or altered drawings shall show the nature of the amendment or alternation in a revision block on the drawing, together with the revision number or letter and the date of the revision.

The contractor shall be responsible for any discrepancies, errors or omissions in the drawings and other particulars supplied by him whether such drawings and particulars have been approved by the Engineer or not, provided that such discrepancies, errors or omissions are not due to in curate information or particulars furnished in writing to the Contractor by the Engineer.

8.4.3 Technical Literature of Equipment

Technical literature of all equipment proposed to be used in the system inclusive of dimensional drawings, capacity tables & other selection data, certificate of compliance, test reports and other relevant information shall be supplied in triplicate for the Engineer to determine the adequacy and suitability of the equipment for the proposed fire protection system.

All the documents shall be in language of English. Selection data shall be submitted in triplicate and shall consist of engineering selection tables provided by the manufacturer.

These documents in required number of copies specified should be handed over to the Engineer and Engineer required minimum 21 days to check and give the approvals. So, by preparing the working schedule, contractor may consider that time period for submission.

8.4.4 Monthly Progress Report

Contractor shall submit a detailed report to the Engineer by presenting the progress of work at site for each and every month. The report shall include with photographs of site premises to validate the facts mentioned in the report.

Actual completion time for each and every task shall be analyzed with the scheduled time target stipulated in the Schedule of Contract Work. The contractor shall justify the

reasons for lapsed tasks and shall submit a proposal to expedite the same work to aligned with the scheduled time targets.

8.4.5 Maintenance & Operating Manuals

Maintenance and operating manuals of all equipment supplied shall be furnished in triplicate with detailed diagrams of the equipment, piping & valve arrangements and instructions of the regular maintenance of the equipment.

Frequency of lubrication and specifications of the lubricants recommended shall also be provided. All manuals should be printed, and ring bound with a schedule which may be in the form of a material list giving all particulars together with ordering references of all replaceable parts for all the equipment which will be supplied.

8.4.6 Samples

Samples of all materials to be supplied under the contract such as pipes and multiple fittings such as valves, strainers, electric components shall be supplied to the Engineer for approval. Such samples shall be kept with the Engineer until completion of the Works and same will be released to the Contractor on completion of work. The items of supplies used for the project shall be at least equal in quality to the approved sample.

All the samples shall be clipped/ mounted on a timber board with white colour finished and each item shall be labeled in black colour, indicating equipment name, make, model number and serial number. The project name shall be mentioned at the top of the board and the details of the Contractor shall be mentioned at the bottom of the board.

8.4.7 As-Built Drawings

On completion of the installation, the Contractor shall prepare a set of As-built drawings incorporating all changes made to the original design and drawings, which drawings shall represent an accurate description of the installed systems. These drawings shall be bound with covers into an album and handed over to the Engineer.

8.4.8 Handing Over Documents

The final handing over documents to be submitted by the Contractor on completion of the installation shall comprise the following:

- a) Operation and maintenance manuals (3 copies)
- b) Commissioning sheets (3 copies)
- c) Test reports (3 copies)
- d) As built drawings (3 hard copies and 1 soft copy in CD)

These documents, in required number of copies specified, should be supplied to the Engineer within 30 days on issue of taking over certificate.

8.5 Testing and Commissioning

Bidder shall submit with the Bid, a complete proposal with time schedule for testing and commissioning of the fire detection and protection system. The program shall include a trial operation of all main equipment with any necessary adjustments to ensure that the system is working correctly. The Contractor shall provide all instruments and equipment together with commissioning engineers and adequate assistance for carrying out the commissioning and testing activity which shall be done in accordance with the recommendations of relevant Standards. If any portion of the works fails to pass the tests, the Contractor shall, at his own expense carry out such alterations or replacements as are required to the satisfaction of the Engineer. The Engineer shall be at liberty to call for further commissioning when such alterations have been completed to their satisfactory. The Contractor shall provide commissioning spares at his own expense.

Spare parts earmarked for maintenance shall not be used during this period.

- (i) When the lift is completely installed it shall be subject to the complete range of tests not limited to the EN-81-1 and EN-81-72 and required to demonstrate to the Engineer the following:
 - (a) Insulation test, earth continuity and impedance test.
 - (b) That the lift operates at specified speed at loads varying between no load and 110% load.
 - (c) That the brake sustains the car with 125% contract load.
 - (d) Satisfactory operation of the safety gear and over-speed governor under over-speed conditions (drop test).
 - (e) That the various safety devices, locks and other safety provisions operate as intended.
 - (f) That the operation of the lift and doors in response to the car switches and push buttons is as intended.
 - (g) That the leveling is correctly adjusted for each floor and remains so after extended use.
 - (h) The car shall be loaded to the full specified load and the lift run from top to bottom continuously, for the full travel of the lift, allowing the normal time interval at each terminal, during which the doors are to be opened and closed. The test shall be continued for 2 hour during which the gearless permanent magnet synchronous motor shall be assumed to have attained their maximum operating temperatures.
- (ii) Any other test specified in EN-81 all parts (Specification for testing and inspection of electric and hydraulic lifts).
- (iii) All certified test weights, material and instruments required for the tests shall be provided by the Contractor.

8.6 Servicing and Maintenance on Provisional Acceptance

- (a) After provisional acceptance, when the lift is put into service, the Contractor shall maintain lifts as necessary, for a period of twelve months.
- (b) All necessary stores, spares, tools and other material required for such work shall be provided by the Contractor.
- (c) An efficient local breakdown call-out organization whereby the services of an engineer can be obtained immediately at any hour of the day or night will be deemed to fulfill the above requirements.

All equipment and installations provided under the Contract shall be continuously maintained free of charge by the Contractor throughout the whole maintenance period of twelve months including routine service and maintenance, periodic checking, inspection, adjustment etc., as deemed necessary to guarantee smooth and uninterrupted service.

The Contractor shall replace or repair with utmost speed and at his own expense any point of the plant or equipment or material or work performed or furnished under lifts works in the contract which may prove defective in design, installation and erection, operation, performance workmanship or from any act of omission of the Contractor that may develop, under the conditions provided by the contract and under proper use in the works or any section thereof during the maintenance period after the work.

The Contractor shall obtain and submit to the Engineer any guarantee or certificates of warranty available from the manufacturers but only as supplementary to the Contractors own guarantees and in no way invalidating them.

At the end of monthly services and inspection, complete service report shall be handover to the engineer in charge.

8.7 Instructions to Employer's Staff

The Contractor shall, at times agreed with the Engineer, instruct the Employer's staff in the correct use, operation and routine maintenance of the works and shall satisfy himself and the Engineer that the staff are competent to take over and operate the Works.

8.8 Maintenance Contract

Together with his tender the tenderer shall submit a draft contract for comprehensive maintenance, regular inspections of the installations and equipment after the expiry of the Defect Liability Period. Details shall be given for a comprehensive scheme inclusive of all replacement spares. Charges shall be given for a period of 5 years after the Defects Liability Period.

Contractor shall handover the completed service report at the end of each monthly service for each Lift.

9 DETAILED TECHNICAL SPECIFICATIONS FOR VERTICAL TRANSPORTATION SYSTEM (PASSENGER AND FIRE)

Vertical Transportation System of the building shall consist of two (02) Passenger Lifts – *Machine Room type (MR)* and Fire Lift *Machine Room type (MR)*.

9.1 Scope of Work

The scope of the works under this contract shall include but not limited to the following.

- A. Supply, Installation, Testing & Commissioning and Maintenance of machine room type 02 Nos. of Passenger Lifts (Lift L1 & L2)
- B. Supply, Installation, Testing & Commissioning and Maintenance of 01 Nos. of Fire Lifts (Lift FL1).

9.2 Standards

Unless otherwise specified, the whole of the works shall conform to the following standards:

- * Relevant parts of BS. EN 81-1 and EN 81-70:200.
- * Relevant parts of BS. EN 81-72.
- * IEE Regulations for Electrical Equipment in Buildings.
- * Regulations and Recommendations of the Ceylon Electricity Board and the Sri Lanka Standards Institution. Other recognized national or international specifications, not less exacting than those above may be used, provided the latest edition of such specification (in English) had been furnished with the tender and accepted.

9.3 Drawings and Specifications

The Contractor shall furnish with his tender, drawings of the general arrangement of proposed Lift equipment, depth of pit, overhead height, minimum required dimensions of hoist way and machine room if relevant and necessary specification.

The tender drawings are generally diagrammatic and indicative of work to be carried out. The Contractor shall furnish the following documents, drawings, diagrams and schedules for approval by the Engineer.

- i. General arrangement drawings showing layout of lift well positions of all plant and equipment, ancillaries, cable trunking, conduits etc.
- ii. Loads on machine room floor slab if relevant, beams and pedestals.
- iii. Details of landing entrances.
- iv. Details of block-outs, holes and built-in fixing devices to be incorporated in the civil works.

- v. Details of car enclosure design, finishes, car and landing station panels, interior lighting and ventilation.
- vi. Electrical wiring diagrams, schematics, layouts for the entire installation.
- vii. Coordinated wiring/connection details between equipment and cables, showing terminal block coding, cable core size and identification.
- viii. Operation and maintenance manuals.

Working diagrams shall be provided in respect of all electrical equipment and/or systems, which form part of the works. Under this contract, schematic layouts shall be presented in ladder or similar format such that it is possible to comprehend the operation of a particular system, the interconnections between various systems, and to identify the components, wiring/connections shown on the diagrams.

A set of detailed drawings must be submitted for approval as soon as possible after the order is placed showing detailed general arrangements, wiring details, and holes to be provided in walls and floors. All the drawings must be approved by the Engineer before the work commences.

9.4 Related Civil Work

(a) Civil Work

All related civil work such as breaking and chipping of concrete to enlarge openings or to provide new openings where ever necessary, re-building/finishing of openings after installation of equipment and accessories where ever necessary, construction of any related new concrete beams (*such as landing sill support*), brick work or block outs etc. shall be carried out by the lift contractor.

(b) Steel Work

- i. The Contract shall include supply and erection of the steel work required for the support of machines, sheaves, guides, door tracks etc. complete.
- ii. The contractor shall supply and fix suitable capacity lifting hooks required for maintenance and erection works.
- iii. A substantial galvanized steel cat ladders for all lift pits shall be provided as per BS Codes and fixed by the Contractor to give easy means of access to the pits.
- iv. All guard rails and ladders in the lift machine rooms if relevant shall be supplied and fitted by the Contractor.

9.5 Traction Drive

Motor

The traction machine shall be gearless and with permanent magnet synchronous motor. The motor shall be specially designed to meet the severe load conditions encountered in lift service. It shall be suitable for local ambient conditions.

The starting current shall not exceed 2.5 times the rated full load current of the motor and bidders shall specify in the tender specification, the rated full load current and the starting current of the offered motor.

The drive system shall incorporate all accessories and equipment to produce smooth starting, acceleration, running, deceleration and stopping characteristics for maximum riding comfort.

Thermistors shall be incorporated in the motor windings to give protection against overheating.

The continuous duty cycle rating shall be as stated in the Appendices and the motor shall have a minimum of class F insulation.

The machines shall run at all loads without appreciable noise or hum.

Brakes shall be designed to be instantly and automatically applied in the event of interruption of the power supply from any cause.

The traction machine and its electrical components shall be protected from dripping and splashing water or provided with enclosures classified to at least IPX3. The machines shall be protected from malfunction caused by water.

9.6 Controller

The lift controller shall be of vertical, totally enclosed, sheet steel cubicle type with hinged door in front and screwed panels at the rear providing easy access to all components inside the controller.

The enclosure shall be well ventilated by means of louvers or other means devised by the lift manufacturer. Adequate protection shall be provided to prevent the entry of harmful insects and vermin into the cubicles.

The panels shall contain contactors, relays selectors, timers, transformers, fuses, rectifiers and all apparatus associated with the control of the lift at the top of the lift shaft or machine room.

The controller shall provide protection against the following:

- * No-volt and sustained under voltage
- * Phase reversal of the power supply
- * Overload
- * Failure of any one phase

The controller shall cut-off the current automatically, apply the brake and bring the car to a standstill in the event of the failure of any of the electrical safety devices. The controller circuits shall be designed to prevent the lift being operated by the main motor until car and landing doors are closed, except within the leveling zone of the floor at which the lift is stopping.

The solenoids, magnetic brake and other magnetic devices shall operate on D.C. obtained through a full-wave rectifier. All operating coils shall be adequately rated, insulated and vacuum impregnated against moisture and shall be capable of withstanding a minimum of 10% over-current and 20% over-voltage.

The contactors and switches shall be mounted on panels of approved non-inflammable and non-hygroscopic insulating material supported on steel frame. All switches and contactors shall be of adequate rating of non-weldable wiping type. Heavy current relays shall be provided with arc deflectors.

9.7 Electrical Work

The power supply for the apparatus will be 400 Volts AC $\pm 10\%$, 50 cycles, 3-phase 4 wire with neutral earthed at the supply source. The main beams, runways and the steel structure should be connected to the main Earthing System. The installation shall be protected against over voltages and power surges by surge arrestors. Contractor shall also supply and install any other switchboards or panels required for a complete installation.

- (i) Power Supply to the lift machine room of to the top of the lift shaft is terminated on 3 phase circuit breakers at lift machine room of top of the shaft. The contractor shall draw the power supply for the lift installation from these breakers. The supply shall include all required cables, fuses, electrical power panel, and other accessories. The installation shall be protected against over voltages and power surges by surge arrestors.
- (ii) PVC insulated cables shall be 450/750 Volt grade, manufactured in accordance with BS 6004 or equivalent.
- (iii) All electrical wiring shall be run in galvanized steel conduit and/or trunking, all as specified below. Trunking shall be used wherever possible instead of multitude of conduits.
- (iv) The electrical wiring of Fire Fighter's lift shall be carried out according to the EN 81-72 and related fire protection standards using standard material and accessories other than those described below.
- (v) The power supply to the lift, lighting, ventilation fan and door motors will be given from primary and secondary (emergency, standby or alternative) supplies.

- (v) The power supply to controller and emergency landing device shall be given from the Automatic power transfer panel which is fed by both power supplies.

9.8 Conduits

The rigid and flexible conduits shall be made with GI.

- (i) The conduits shall be of sufficiently large section and so arranged with draw-in boxes to allow either and easy drawing or out of the cables which must not exceed the number set out in the appropriate table of the IEE. Regulations for electrical installations and no conduit bearing rust or damage shall be used.
- (ii) Surface runs shall be fixed by means of galvanized distance saddles at intervals not exceeding 1200 mm.
- (iii) Conduits shall be mechanically and electrically continuous throughout.
- (iv) No conduit shall be less than 20mm outside diameter.
- (v) No cables shall be drawn into conduit before fixing and the conduit shall be cleaned and free from oil before erection.
- (vi) Standard fittings such as couplings shall be used for installation.

9.9 Conduit Boxes

- (i) Conduit boxes shall be fixed direct to the structure apart from the support provided by the conduits.
- (ii) Boxes lids where required shall be heavy gauge secured by means of screws.
- (iii) Adaptable boxes and lids of the same size shall be interchangeable.

9.10 Trunking

The electrical installation for the Lift in the shaft and machine room if relevant shall be done with mechanical protection by means of GI trunking.

- (i) The outer case, lid and internal partitions, if appropriate, of the trunking shall be manufactured of galvanized sheet steel enameled finished in manufacturer's standard colour.
- (ii) The lid of the trunking shall be formed with returned edges and shall be fixed to the cable trunking by means of screws located in bushes set in the edge trim of the trunking, or by other approved securing devices.
- (iii) Lengths of trunking shall be coupled together by suitable means.
- (iv) At each joint in the trunking, continuity shall be maintained by the installation of copper links by brass nuts, locking washers and bolts. In addition, an earth continuity conductor copper shall be run within the trunking and used to bond all items of equipment.

- (v) Before cables are drawn into trunking the Sub-contractor is to ensure that all sections of trunking are free from sharp edges, burrs and weld spots which could cause damage to cable insulation.
- (vii) All trunking required in the floor of the lift machine room if relevant shall be installed flush with the floor finish and be fitted with removable chequered plate lid.
- (viii) Any damage to the paint work of the trunking shall be made good by the Contractor before cables are drawn in.

9.11 Bonding

- (i) Supplementary bonding conductors shall be provided to connect together all exposed conductive parts and extraneous conductive parts of the lift installation in the well and machine room if relevant.
- (ii) External conductive parts of the lift installation and exposed conductive parts of well lighting and power installation shall also be bonded.

9.12 Traveling Cables

Traveling cables between car and lift well shall have flame retarding and moisture resisting outer cover. They shall be flexible and suitably anchored and suspended to relieve strains in the individual conductors.

Travelling cable shall comprise with screened video, data & audio cables.

9.13 Suspension Ropes

- (i) The suspension ropes shall be from a specialized rope manufacturer and specially manufactured for elevators, each capable of sustaining the weight of the laden car with safety.
- (ii) The suspension ropes shall comply with relevant EN standard and the number of ropes and sizes shall meet the requirement of EN 81-1.
- (iii) The manufacturer's test certificate for the ropes shall be provided

9.14 Counter weight

- (i) The counterweight shall be provided consisting of cast iron weights or steel plates contained in a structural steel frame with suitable guide shoes.
- (ii) After balancing the counterweights should be locked in position by bolts to avoid noise and sliding.
- (iii) A rigid metal screen shall be provided around the counterweight at its lower end of travel.

9.15 Sheaves and Supporting Beams

Deflector and overhead sheaves shall be provided where necessary to obtain the proper lead of the ropes to the car and counterweight, together with supporting beams for the same.

9.16 Hand Gear

- (i) Provision shall be made for moving the car to a floor level by hand in the event of the lift stalling between floors. Hand winding equipment shall be painted yellow.
- (ii) The brake-lifting device shall be so arranged that it is impossible for the brake to be left in the fitted position.
- (iii) The direction of winding corresponding to the raising and lowering of the lift car shall be clearly indicated.
- (iv) A prominent notice shall be displayed stating that hand winding shall be undertaken only by authorized persons and the notice shall detail the step-by-step procedures to be taken to move the lift in an emergency.
- (v) If special tools are required, they shall be retained in a suitable wall mounted fixture.

9.17 Safety Gear and Governor

- (i) The safety gear to BS EN-81 shall be mounted on the car frame and shall be operated by a centrifugal over speed governor located over the lift well. The safety device shall be arranged to bring the car to a stop and hold it on the guide rails in the event of excessive descending speed and provision shall be made automatically to shut off the power supply to the motor and apply the brake.
- (ii) Provision shall be made for easy release and resetting of the safety gear after it has been operated.
- (iii) Governor ropes shall be of steel not less than 8 mm in diameter.
- (iv) For elevator speeds of 1.0 m/s and above, gradual safety should be used. For 0.75m/s and below, instantaneous safety can be used.
- (v) Type test certificate shall be submitted for the installed model.

9.18 Buffers

- (i) Buffers to BS EN-81 shall be provided.

- (ii) Where buffers are installed in the pit they shall be mounted on continuous channels or other structural member fastened to the guide rails.
- (iii) Spring buffers should be used for speed up to 1.0 m/s and for speed above 1.0 m/s, spring return type oil buffers should be used.
- (iv) Type test certificate shall be submitted for the model fixed.

9.19 Compensation Ropes

Where required by BS EN-81, compensating ropes shall be provided between the car and counterweight and passing round a pulley in the pit if recommended by manufacturer. The ropes shall be tensioned by gravity and a safety switch shall be provided.

9.20 Guides and Fixings

Guides for car and counterweight shall consist of steel "tee" section machined rails or formed rails erected plumb and securely fastened to the lift well by heavy steel brackets. The ends of guides shall be tongued and grooved or forming matched joints and shall be connected with steel fish plates and bolts necessary for fixing the guide rails to the building structure.

9.21 Guide Rail Lubrication & Guide Shoes/Guide Rollers

- (i) Self-lubricating type of guide shoe shall be provided for the car and counterweight.
- (ii) Guide shoes shall be provided with replaceable nylon liners to absorb the shocks and to give good riding comfort.
- (iii) Where wicks lubrication is used, a drip pan shall be provided below the guides in the pit to catch surplus oil.
- (iv) At least 3 guide rollers shall be used for Roller type guides.

9.22 Car Frames

- (i) The car frame shall be constructed of steel members reinforced and braced to relieve the car enclosure of undue strains in the event of the operation of the safety gear or by the lift being arrested in its travel by impact with the buffers.
- (ii) Adjustable guide slippers shall be fixed on the top and bottom of the frame.
- (iii) For 1:1 roping arrangements, the steel suspension ropes shall be attached to the car frame with provision for taking up any inequalities between the ropes.

- (iv) Rope should be connected to thimble rod either by wedge type terminating device or by babbitt metal molding and springs should be fixed between suspension and car frame to avoid transmission of vibrations to the car.

9.23 Car Platform

An adequate floor of steel construction shall be provided. The floor covering will be provided as part of this sub-contract and secured to the flooring. The platform shall be equipped with a sill of finish as indicated in schedule of requirements.

9.24 Car Enclosure

The design shall in general conform to the following requirements.

- (i) The car shall be of metal construction, with the walls and doors, car fittings in a finish indicated in schedule of requirements attached herewith.
- (ii) The car of the passenger lifts shall include a fitted stainless steel finished handrails on side walls.
- (iii) The panel housing, the car operating micro touch buttons and other car controls together with the cabinet for housing the telephone/intercom inside the car shall all be finished in stainless steel. Micro touch buttons should not have mechanical displacement of more than 0.5 mm.
- (iv) Lighting shall be provided by means of LED lamps concealed above a dropped ceiling. Power supply for the lighting circuit shall be taken from the lift machine room if relevant.
- (v) Mechanical means of ventilation shall be provided in the design of the car enclosure consistent with the designated occupancy of the lifts.
- (vi) The roof of the car shall be sufficiently reinforced to withstand the distributed weight of two men.
- (vii) Car shall be fitted with emergency hatchway on the roof for emergency purposes. It shall have a minimum size of 450mm x 500mm and open outwards.
- (viii) Toe guard to be provided for full entrance opening width.

9.25 Landing Doors and Entrances

The Contractor shall furnish and install at all landing openings, complete metal entrances consisting of frames, architraves, doors, sills and toe guards, in accordance with the following: -

(a) Architraves

The frames shall consist of head and jamb sections with integral trim. On the well side the frames shall be carried back far enough to present a neat appearance, and shall be secured to the sill and door hanger supports, or structure. The architraves on all floors should cover full thickness of entrance wall. Finish should be as indicated in schedule of requirements.

(b) Sills

The sills shall be of finish as indicated in schedule of requirement with approved non-slip wearing surface. They shall be in one piece of sufficient length to suit the two supporting struts and grooved for the door guides. The door tracks shall be self-clearing. Sill shall be well fixed to the lift shaft with 100x100 mm Angle iron supports.

(c) Landing Doors

Doors shall be of the type specified in the schedules. The door panels shall be formed to match the unit frames. The bottom of the doors shall be provided with guides to run in the sill slots with minimum clearance. Door hanger rollers to have non-metallic contact with the header track for smooth door operation. The doors shall have a minimum fire rating of 1 hour.

(d) Toe Guards

All landing sill to be provided with "Toe Guards" for the full width of the entrance opening.

9.26 Car Doors

- (i) The entrances shall be protected by horizontal sliding metal doors with finish as indicated in schedule of requirements. The opening arrangements are detailed in the schedule of requirements. Panel rigidity shall be obtained by suitable steel reinforcement. The doors shall have a minimum fire rating of 1 hour.
- (ii) The doors shall be hung on sheave hangers running on a polished steel track and guided at the bottom by non-metal shoes sliding in a smooth threshold groove. Door hanger sheave to have non-metallic contact with the track for smooth and noiseless door operation.
- (iii) Suitable means shall be used to transmit motion from one door panel to the other.

9.27 Car and Landing Door Mechanism

- (i) An automatic door operating mechanism shall be provided to open and close the car and landing doors when the car is at a landing. The car door and landing door at any landing shall be opened and closed simultaneously. They shall be power

opened and closed. Door movements shall be cushioned or checked at both limits of travel.

- (ii) The doors shall be automatically opened when the car is level at the respective landing and shall again close after a pre-determined time interval has lapsed. A 'door open' button shall be provided in the car the momentary pressure on which shall reverse the motion, reopen the doors and reset the time interval.
- (iii) The car door shall be provided with a protective device extending the full height and projecting beyond the front edge of the door. This device shall be so arranged that should it touch a person or any obstruction in its path while the door is closing, it shall automatically cause both the car door and the landing door to return to the open position. The doors shall remain open until the expiration of a time interval and then close automatically. The pressing of a car close button, once the doors are fully open shall cause the doors to close immediately.
- (iv) Mechanical safety edges shall be retractable. In center opening doors, both doors shall have safety shoes.
- (v) The device is to be arranged so as to ensure the doors exerting the absolute minimum force on a person obstructing the closing operation.
- (vi) In addition, photoelectric detector type of door safety device shall be provided. So that there is no need to continue to press the door opening button while boarding or alighting.

9.28 Car and Landing Door Interlocks

- (i) Each landing door and the car door gate shall be equipped with an electro-mechanical interlock, which shall prevent the operation of the lift unless the doors are closed and positively locked.

The interlock shall also prevent the opening of any door until the car has reached the respective landing zone with the operating circuits open.

- (ii) Emergency opening of the door and gates from the landings shall be possible by means of key operation. Two keys shall be provided.
- (iii) Type Test certificate shall be submitted for the model fixed.

9.29 Emergency Back-up System

In the event of a microprocessor malfunction, another discrete circuit is energized to maintain the functioning of the system and assure operational safety.

9.30 Landing and Car Controls

The lift shall be controlled from micro buttons in the car, numbered to correspond to the landing served, and by two buttons on the landing.

The operating device shall give the person in the car uninterrupted use of the lift until the car door has reached the desired landing, and the car has been opened and again closed. Momentary pressure of a landing button shall bring the car to that landing.

After the car stops at a landing response to a landing call, a time delay shall render the car inoperative from the landing buttons for a pre-determined interval.

9.31 Top of Car Inspection Controls

- (i) Inspection controls shall be fitted to all passenger-carrying lifts in accordance with BS codes.
- (ii) A 13 Ampere 3 pin switched socket outlet and a permanent light of the protected bulkhead or wall glass type with controlling switch shall also be provided on top of the car. The supply for this socket outlet and lamp shall be independent of the lift machine supply.

9.32 Emergency Opening

- (i) Each lift car shall be provided with emergency trap door to the standard on the roof for emergency rescue purposes.
- (ii) Panels for emergency openings shall:
 - * Not open inwards;
 - * Be clear of any apparatus mounted above the roof of lift car;
 - * Be held by suitable fasteners, which can be opened only from outside the lift car (i.e. without key)
 - * Be provided with a switch, which will prevent operation of the lift when the panel is open, and which will restore operation of the lift only when the fastenings have been manually restored.

9.33 Terminal Stopping Devices

Lift shall be fitted with upper and lower normal stopping devices and upper and lower final stopping devices each of which shall independently be capable of stopping the car through its own switch. If the lift has passed a final limit switch it shall not be possible to clear the circuit until the lift has been moved back by hand into its normal running position.

9.34 Emergency Switch In Lift Pit

A switch shall be provided in the pit for each lift in accordance with EN-81 which, when placed in the "STOP" position, will cause the lift to stop and prevent its being started until placed in the "RUN" position.

9.35 Alarm Bell

A push button shall be fitted on the control panel in car arranged to ring a battery-operated bell situated near the entrance to the lift on the ground floors, the precise position to be agreed on site. Bell, trickle charger, lead acid (planet type) battery and all interconnecting wiring shall be supplied and installed as part of this contract.

9.36 Emergency Lighting

The lift car shall be provided with an emergency light, which will operate for not less than three hours duration on mains failure. The battery to be rechargeable type. The light shall consist of a self-contained unit with its own batteries and a small fluorescent tube.

9.37 Indicator

All indicators shall be fitted in accordance with the specifications in technical schedule.

9.38 Car Load Weighing Device & Automatic By-Pass

- (i) The lift car shall be fitted with a car-weighing device to render the lift inoperative should the contract load be exceeded. Visual and audible indication that the car is overloaded shall be fitted within the car. When the overload has been removed, the lift shall resume normal operation.
- (ii) In the event of the car being loaded to its full capacity, then it will not stop to answer any hall calls and will stop only at the registered car hall. This will continue until such time the loading is reduced from its full capacity. This operation shall be in both directions of travel.

9.39 Interphone System

An intercommunication system between the car, ground floor lift entrance and the respective machine room if relevant shall be provided in the lift.

The station within the lift car shall be mounted above the car-operating panel having a perforated speaker grille. Pressing the interphone alarm push button in the car-operating panel shall cause the buzzer to operate and initiate an audible and illuminated signal in the Machine.

In the event of a failure of the normal electrical supply, the intercom system shall be automatically switched onto an emergency battery supply system provided with an automatic battery charger capable of fully recharging a discharged battery within 72 hours.

The entire installation and wiring of this shall be carried out by the lift contractor.

9.40 Arrival Gong

Arrival Gong strikes indicating arrival of the cabin at a particular floor.

9.41 Painting

- (i) All iron except where finished bright or plated shall be thoroughly cleaned of all scale and rust and painted two coats of oil resistant paint at maker's works. On completion of the work on site the paintwork shall be touched up to make good any damage sustained during installation. All bright and plated parts should be greased or otherwise protected against corrosion and discoloring during erection.
- (ii) Cellulose and other special finishes shall be protected so that they are handed over in perfect conditions.

9.42 Vibration

All lift gear including traction motor and controllers shall be as silent in operation as possible and in addition are to be effectively insulated from the structure so that in the opinion of the Engineer no noise or vibration is transmitted to other parts of the building.

9.43 Radio Interference Suppression

The lift equipment shall be fitted with radio interference suppression components during manufacture to ensure that the limits of interference comply with BS 800. All components and filter units used for interferences suppression shall comply with BS 613.

9.44 Fire Emergency Service

Fireman's switch shall be provided and located in the ground floor close to entrance of the lifts and when activated during an emergency the lifts should come to the ground floor and doors shall immediately open. Further provision shall be made in the lift control system to receive signals from the fire detection system and activate all lifts to travel automatically to ground floor and doors shall be immediately opened in a fire situation.

In case of a fire situation, the lift shall be suitable for use by the fire fighters for rescue of occupants of the building who have been affected by the fire.

9.45 Automatic Rescue Operation

In the unlikely event, that an elevator should stop between floors, the cause of malfunction will be checked out automatically and when safety has been confirmed, the elevator will proceed at low speed to the nearest floor, so that passenger can alight.

9.46 Car Operation and Control System

The operation shall be of the selective collective type. The operating device shall consist of a series of car call buttons in the car, numbered to correspond to the various landings, 'Up' and 'Down' buttons at the intermediate landings and single button at the terminal landing, all connected electrically with the microprocessor governing floor selection and direction of travel to supply the operation described below.

9.47 Disable Facilities

The floor space of lift should be sufficient for wheelchair user to enter the lift and maneuver within reach of the controls and to exit. Lift door should be wide enough for wheelchair users and lift door closing mechanisms should be adjustable to give adequate entry time. Landing Operating Panel (LOP) and Car Operating Panel shall be provided at a height that is within easy reach of any and by use by wheelchair users in addition to the standard LOP and COP. All control buttons should include Braille, have raised numbers and have symbols to indicate "Open" and "Close".

9.48 Attendant Service

The operating mode of an elevator could be changed to attendant mode from normal fully automatic mode by an override switch as and when required. Switch should be located inside the enclosure of the car operating panel. Upon registration of call the direction arrows in the car should be illuminated to indicate the service direction of the car.

10 DETAILED TECHNICAL SPECIFICATIONS FOR PASSENGER LIFTS INSTALLATION

10.1 Schedule of Requirements – Passenger Lifts (Machine Room Type) – L1 & L2

Type of Elevator	- Passenger
No. of Lifts	- 02 Nos.
Capacity	- Minimum 1000 kg
Speed	- 105 m/min (1.75 m/s)
Duty	- 180 starts/ hr.

Automatic Re-leveling Accuracy	-±5mm
Traction Drive	- Gearless Permanent Magnet Synchronous Motor
Drive Unit	- AC Variable Voltage Variable Frequency Control
Operation	- Selective collective with or without attendant service
Stops & Openings	- 11 (One opening same side)
Service Floor Names	- B, GF-8F, Roof Terrace
Travel length	- 40,050 mm (Approximately)
Overhead Height (Available)	- 4,700 mm
Pit Depth (Available)	- 1,500 mm
Hostway Size (Available)	- 2,285 mm (W) x 2,500 mm (D) (Approximately)
Car and Landing Door	- 900 mm (W) x 2,100 mm (H) / 2-Panel Center Opening
Minimum Car Dimensions	- 1,600 mm (W) x 1,500 mm (D)
Machine Room	- Machine Room (MR)
Standard	- EN 81-1
Door Jamb	- Narrow

10.2 Schedule of Requirements – Fire Lift 01 (Machine Room) – FL1

Type of Elevator	- Fire Lift
No. of Lifts	- 01 Nos.
Capacity	- Minimum 1,600 kg
Speed	- 105 m/min (1.75 m/s)
Duty	- 180 starts/ hr.
Automatic Re-leveling Accuracy	-±5mm

Traction Drive	- Gearless Permanent Magnet Synchronous Motor
Drive Unit	- AC Variable Voltage Variable Frequency Control
Operation	- Selective collective with or without attendant service
Stops & Openings	- 11 (One opening same side)
Service Floor Names	- B, GF-8F, Roof Terrace
Travel length	- 40,050 mm (Approximately)
Overhead Height (Available)	- 4,700 mm
Pit Depth (Available)	- 1,500 mm
Hostway Size (Available)	- 2,500 mm (W) x 3,000 mm (D) (Approximately)
Car and Landing Door	- 1200 m (W) x 2,100 mm (H) / 2-Panel Side Opening
Minimum Car Dimensions	- 1,400 mm (W) x 2,400 mm (D)
Machine Room	- Machine Room (MR)
Standard	- EN 81-1 & EN 81-72
Door Jamb	- Narrow

10.3 Elevator Car:

Car Ceiling, Lighting and Ventilation:

The car ceiling shall be of high quality backed enamel decorative steel sheet with bright recessed LED lighting to minimum illumination level of 150 lux and ventilation by 02 nos electric line blower with slit vents. The cabin lights and ventilation blower shall be supplied through UPS of adequate capacity for 10-minute operation.

Car Walls and Door:

The car wall and doors shall be of hair line finished stainless of SUS 304 or higher, car doors shall be side opening an automatic type complete with 02 nos. safety edges and full

width door sensor. The car walls and doors shall be constructed from materials which would be in accordance with BS 476” Part 7 and have at least 1 hour fire resistance.

Car Floor:

Hardwearing Vinyl tiles with stainless steel kick plate along three sides of cabin.

Car Sill:

Extruded hard Aluminium

Hand Rails:

Round Stainless steel (maximum diameter is 45mm) on side walls of the lift car

Mirror:

Required mirror at rear wall of Passenger Lifts (1&2) and not required a mirror at rear wall of Fire Lift.

10.4 Landings

Landing Architrave: All landing architrave shall be wide splayed made with hairline finish stainless steel of SUS 304 or higher.

Landing Doors at all floors (Clear entrance and Two panel center opening / side opening automatic doors in hairline finish stainless steel of SUS 304 or higher.

Landing doors shall be fire rated for minimum 01 fire.

Landing Sills at all entrances: Extruded hard Aluminum.

10.4.1 Land Operating Panel (LOP) Indicators:

The position and direction indication shall be displayed on LOP.

The land operating panels shall be positioned right to the landing doors and position and direction indication shall be incorporated in the same.

The round/square micro touch type hall call buttons which will illuminate on registration of call shall be installed at every floor landing served by the lifts entrances as shown in the layout drawings. Vertical combined unit comprising Digital car position indicator, direction indicators and Vandal-resistant type, duplex, micro touch hall call buttons which will illuminate on registration of call shall be installed at every floor landing served by the lift.

All metal exposed parts of the indicator's unit shall be made of stainless steel with matt finish.

All metal face plate shall be made of stainless steel with matt hair line finish.

10.4.2 Car Operating Panel (COP) Indicators:

Signals in the Cabin: The following features shall be incorporated in the car-operating panel located at one side of the entrance.

- Emergency stop switch with alarm
- Up/Down travel direction indicators
- Digital floor position indicator
- Floor buttons of micro touch type with registration lamps and those be able to cancel by double touch
- Door opens and door close button
- Interphone
- Audio visual alarm for overload
- Audio visual alarm for fireman operation
- Voice Guidance for announce direction and floor number.

The following switches shall be fixed inside a lockable compartment provided below the panel.

- Inspection switch with up-down push buttons
- Car light switch and Ventilator switch fan
- Lift 'OFF' switch or 'RUN-STOP' switch
- Attendant operation selector switch
- Independent operation selector switch

Car operating panels (2 nos. of COP per lift) shall be mounted on front return panels on **both sides the cabin door** for better operational convenience with call buttons of micro touch type, which will illuminate on registration of a call.

Floor position indicator shall be installed on the top of each car operating panel, which also should indicate up/down direction.

10.4.3 Special Features:

- Safety door edge running full height of car
- DC Alarm bell
- Photoelectric-sensing car door device mounted side by side to the full height to monitor movement of passengers/objects across the door and to control opening and closing of door.

- Arrival gong
- Emergency car light shall be supplied from a rechargeable battery in case of power failure, which could serve the Alarms too.
- Interphone and provision to connect to existing PABX system.
- Overload protective device with audible plus visible indicators
- Recall station in controller
- External Parking switch at Ground floor LOP
- Provision for CCTV camera installation (the travelling cable shall provide data transmission cables for IP based CCTV camera system)
- All required limit switches and interlocks as specified in BS EN-81-1

10.4.4 Emergency Provisions:

- Emergency exits comply with BS EN-81 shall be provided on the car ceiling. These exits shall incorporate the following features.
- Be secured by suitable fasteners for hand use, which can be released only from outside the car.
- The hinged or removable emergency panel shall open outwards of the elevator car.
- The emergency opening shall be clear and no equipment on the elevator car top shall obstruct this opening.
- With the emergency exit opened, it shall not be possible to operate the lift.

Next Landing Device:

If the hoist way doors become jammed by a pebble, debris, etc., preventing opening of the doors, passengers will not be able to alight from the car. In order that the passengers do not get stranded at the affected floor, the elevator shall proceed to next immediate floor and the doors shall open out automatically.

Operation during power failure:

In the case of power failure car emergency light, ventilation fans and door motor drivers shall come ON and automatic rescue system shall slowly guide the elevator to the nearest floor and then open both the car and landing doors automatically to prevent passengers being trapped in the lift car. When power is restored, the elevator shall resume its normal operation.

Parking Operation

A separate parking switch shall be fixed on Ground Floor LOP for the lift and it shall be bringing the lift down after responding all registered calls, stops, opens the doors and close again after preset time with the lights and fans turn off.

Fireman Service

A 'fireman' switch shall be provided at Semi Basement Level for each lift in a break glass at 1.8 heights for operating the Fireman switch. Lift shall return immediately to the Semi Basement Level and door shall open to move out the passengers.

This operation shall be possible to achieve from fire control panel and separate dry contact shall be available at lift control panel.

After returning to the Semi Basement Level the Lift can be operated by firemen on his judgment to use for rescue operation during fire situation.

Low speed automatic Rescue operation:

In the unlikely event that the elevator should stop between floors, the cause of the malfunction shall be checked out automatically and when the safety has been confirmed, the elevator will proceed at low speed to the ground, so that the passengers can alight from the car.

Multiprocessor Backup System:

This system shall assure complete functional backing between the group controller and individual car controllers as well as between microprocessor components in the controller. Thus, safe elevator functioning is assured even if localized malfunctions occur.

10.5 Exhaust Fan

In order to remove the heat generated by the elevator equipment an exhaust fan shall be installed inside the hoist way at suitable location proposed by the lift manufacturer to maintain required conditions. The bidder shall furnish the maximum permissible temperature & humidity inside the hoist way together with temperature maintained by exhaust fan.

10.6 Disable facilities for the passenger lifts / fire lifts

Following specification shall be applicable for the passenger/ fire lifts.

Land Operating Panels (LOPS) for Disables: *(Where if applicable / provide provision in same LOP)*

- *Separate Micro touch type hall call buttons with Braille signs and raised tactile buttons, which will illuminate on registration of call shall be installed at every floor landing served by the lift at a 900mm-1000mm from floor level with Disable standard signage. This shall be in addition to the LOPs specified above lifts.*
- *The dwell time of the car door shall be in accordance with the EN 81-70 on the operation of disable LOP.*

Car Operating Panels: *(Where if applicable / provide provision in same COP)*

A separate car operating panel shall be fixed horizontally on side panel at level of 900~1000mm from floor level in complying with EN 81-70 with following features.

- *Floor buttons of micro touch type with lights including Braille and raised tactile number, for registration of commands*
- *Illuminated Door open and door close button with Braille and raised tactile signal and indicating 'Open' and 'Close' signals*
- *Standard signage for disables*
- *The panel button arrangement of the panel shall be horizontal configuration.*
- *Alarm buttons with braille sign and raised tactile sign which activate the built in interphone*

10.7 Other requirements:

Buffers	- Hydraulic
Safety Mechanism	- Progressive type
Guide rails	- As per specification
Counterweight fillers	- Cast-iron or MS blocks
Power supply	- 400 Volts 3 Phase 50 Hz
Lighting supply	- 230 Volts 1 Phase 50 Hz

10.8 Special requirements Fire Fighter's Lifts

Controllers

- All electrical/electronic control devices, cables and indicators shall be able to operate without malfunction in an ambient temperature range of 0 °C to 65 °C, for at least 2 hours;
- The controller shall ensure the correct functioning of the lift control in smoke filled wells and/or machine rooms for at least 2 hours.

Trap door and Access

- Emergency trap doors of Fire Fighters lifts shall be minimum of 0,5 m x 0,7m except for 630kg lift where the trap door shall be at least 0,4m x 0,5m. and shall be able to open from top of the roof and from inside the cabin (Car).
- Access shall be provided to enable full opening the trap door from inside the lift car, by foldable steps at 0.3m vertical interval and it shall be capable to bear 120kg minimum.

Landing Door

- The all-landing doors and their architraves shall be fire rated for at least 1 hour.

Car and Landing Door Operating Mechanism

- The door opening mechanism, it's protective devices, electric motor and motor drive shall be protected against the splash of water for Fire Fighter's Lift

The COP for Fire Fighting Lift

- g. The Car operating panel shall be protected to at least IP65.

LOPs

- h. The LOPs of Fire Fighter's lift shall be protected to at least IP65

Self-Rescue of Firefighters (Applicable for Fire Fighter's Lift)

- i. Where a rigid ladder is provided with cabin, it shall be attached to the outside of the car for rescue purposes. An electrical safety device in conformity with 14.1.2 of EN 81 Part 1 shall be provided to ensure that the lift does not move if the ladder is removed from its storage place.
- j. Its storage location shall be chosen to avoid creating a tripping hazard during normal maintenance operations.
- k. Where a ladder is provided, its minimum length shall be such that when the lift car stays flush with the landing, the landing door lock of the next upper landing level can be reached. Where it is not possible for such a ladder to be installed on the car then a permanently installed ladder fixed to the well shall be used.

Fire Fighter's Lift Switch

- l. The Fire Fighter's lift switch shall be fixed in the protective lobby intended to be used as the fire fighters service access. The switch shall be located within 2 m horizontally from the firefighters lift, at a height between 1,8 m and 2,1 m above floor level. It shall be marked with a firefighters lift pictogram in accordance with EN 81-72.

10.9 Control System for Fire Fighter's Lifts

The controller shall function according to the Phase 1 and Phase 2 fire service described in EN 81-72 on initiating of the firefighters lift switch.

When the fire fighters service in operation, function of the lift shall not be affected by an electrical malfunction of the group control or other parts of the lift control system located outside of the lift well.

No electrical fault on any other lift in the same group as the firefighter's lift shall affect the operation of the firefighters lift.

The failure and subsequent restoration of electrical power shall not cause any elevator to be removed from Phase I Emergency Operation or Phase II Emergency In-Car Operation.

LIST OF RECOMMENDED MANUFACTURES – VTS SYSTEM WORKS

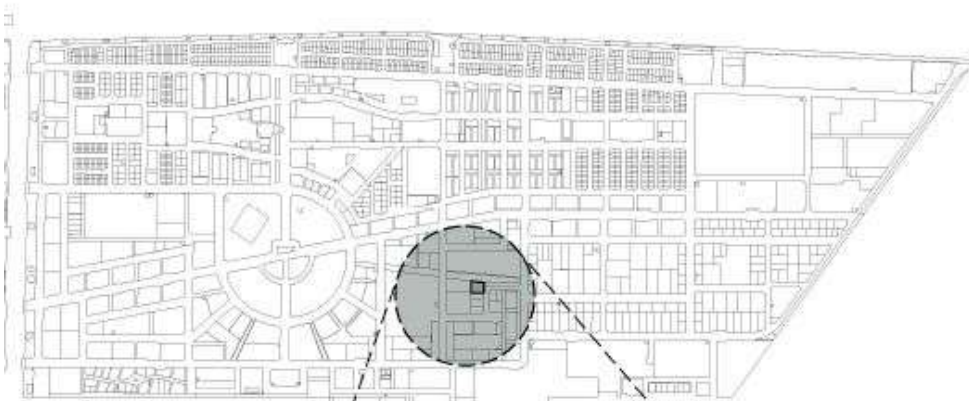
	Item	Manufacturer/Brand Name	Country of Origin and Manufacturing
1.	LIFTS	Mitsubishi Otis Hyundai or Equivalent	Japan/USA/Korea

Note:

The reference made here to certain manufacturers` products and items identified by registered trademarks, this has been done for the sole purpose of defining and establishing standards of quality and performance and not with the intention of restricting the procurement of materials or fittings to a particular manufacturer.

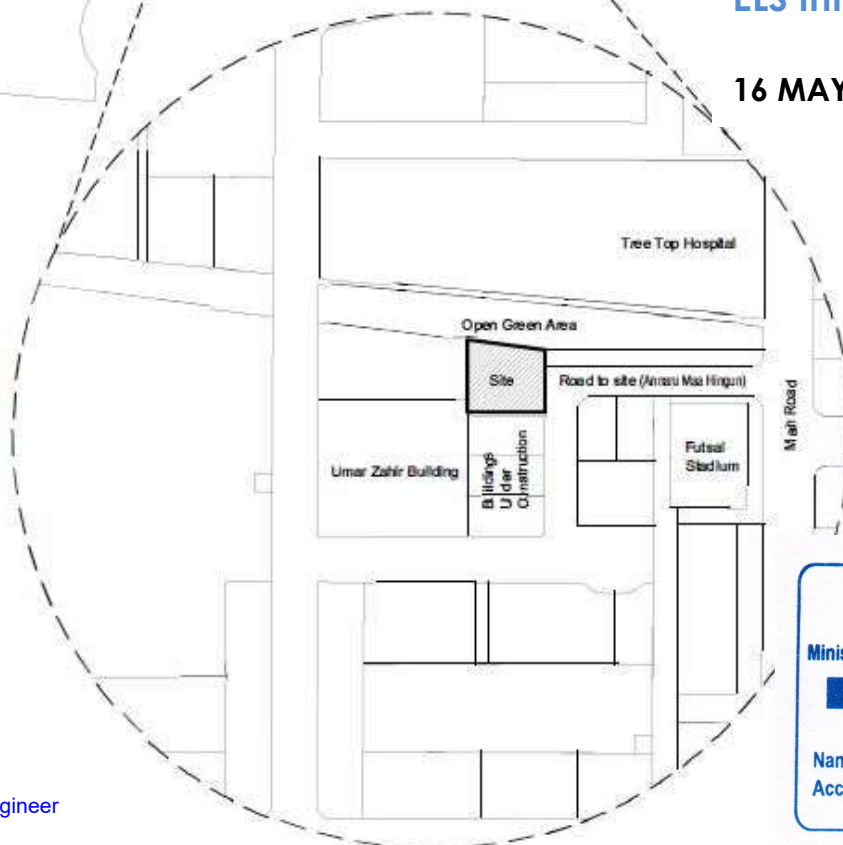
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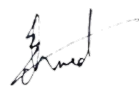
Final Report

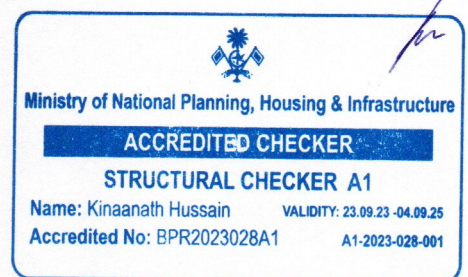


ELS International (Pvt) Ltd

16 MAY 2025




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Report for
DESIGN LINK ASSOCIATES (PVT) LTD

*Geotechnical Investigation for the
Proposed Central Cold Chain Facility
with Climate-friendly Designs at
Hulhumale*

Prepared by

Final Report

OVEI-317

16TH MAY 2025


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Foundation Recommendation
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Approved by



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Document Revisions

No.	Details	Date
1	Final Report	16 MAY 2025



Executive Summary

This Report presents the findings of a review of the ground investigation carried out by **M/s. ELS International (Pvt) Ltd** to determine the geotechnical conditions present within the investigated locations for **M/S. DESIGN LINK ASSOCIATES (PVT) LTD.**

Three boreholes were advanced for the proposed area which was almost flat. This report includes the work carried out by **ELS International (Pvt) Ltd** in determining the sub soil conditions and ground-water conditions along with laboratory investigation at the site, which is performed in arriving design parameters for the foundations from the recommended safe bearing of foundation soil.

The subsoil consists mainly of Dense, medium dense, loose coral sand with porous coral rock fragments. The ground water level along the area varied between 1.60 m to 1.80 m depths from existing ground level at the time of investigation. Recommendations for the foundation is given under the engineering assessment section.



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1 Introduction

This report presents findings from the borehole investigation (SPT analysis) conducted at proposed location identified by structural engineer, Eng. Nandana Abeysuriya in April 2025, on behalf of the **DESIGN LINK ASSOCIATES (PVT) LTD.** The site is generally flat and is bounded by commercial buildings, except on one side, which opens to a green area. The groundwater table varies between 1.60 m to 1.80 m at the time of investigation. The assessments aimed to understand subsurface conditions and potential challenges specific to the proposal of **CENTRAL COLD CHAIN FACILITY WITH CLIMATE-FRIENDLY DESIGNS.** The report outlines methodologies and key findings and provides foundation recommendations for the proposed construction.

1.1 Scope and Format of Report

The geotechnical investigation was performed to assess the soil and rock profile and properties to support the detailed design of the development and understand the geotechnical risks that may be present in relation to the proposed construction. The scope of work comprised the following items:

- Carried out the field tests comprising Standard Penetration tests.
- Inspect & analyze the samples, log and photographs of the borehole.

This report is presented in the following format:

- Desk study information: including geological maps and plans
 - Factual information: comprising description of fieldwork; exploratory borehole logs and in-situ test results
 - Geotechnical assessment: comprising profile definition; general recommendations for selection of foundation solutions, including bearing capacity.
-

2 Desk Study Information

2.1 Site location and boundaries

The proposal is to Construct Commercial building with Climate-Friendly Designs at Hulhumale. The satellite image of the site location retrieved from Google earth is shown in figure 1.



Figure 1:Satellite Image of site area

2.2 Site history and present site use

The reclamation process to increase space/land area is a widely used technique in the Maldives due to the increasing population density or for tourism purposes. Hulhumale Island is also one of the reclaimed islands, intended for tourism, commercial and residential purposes. The proposed site location is also a sand filled area according to past images of google earth.

The satellite images in figure 01 retrieved from Google earth show the history of the site.

2.3 Proposed development

A climate-friendly design has been proposed for the central cold chain facility. According to the design, the proposed area is enclosed by a retaining wall and a structure consisting of three lifts, a fire sump, and a water sump. The site Map is attached to Appendix A.

2.4 General Geological and Sub Grade Characteristic of Site Area

When the underneath geological formation of the site is considered, the coral reef formation is predominated at all the Maldivian islands, it may be stated that a classic atoll chain and the reef limestone, of which they are built, have accumulated on a volcanic ridge foundation associated with a transform fault on the floor of the Indian ocean which is now inactive.

When describing the soil conditions in the Maldives, it has been observed from previous investigations that the structure of the reef flats generally consists of either coral sand, soft or hard coral rock and is usually overlaid with a relatively thick layer of coral sand. On the lagoon side of the reef edge the reef is mostly covered with dead corals and a few colonies of live corals. The cavities between the coral heads are constantly being filled up with coral sand and pieces of broken and dead corals and will ultimately become a substantially hard cemented material.

When considering the climatic characteristics, Maldives experiences a monsoon climate, as the northeast monsoon is from January to March; hot days, cooler nights and relatively dry periods are common feature during this season. The wet, southwest monsoon prevails from mid-May to November. Gales and heavy rainfall occur during this season.

Formation of Coral in the Region

With respect to coral formation, corals are preserved as calcareous skeletons, originally secreted by a simple animal known as polyps. Reef building polyps avoid deep water more than 25m deep and grow optimally at depths within 10m. The sea water temperature should be between 25°C-29°C. Emersion or exposure above water could be tolerated only for short periods during tidal cycles. Salinity levels should generally be between 2.7% and 4.0%. The water turbulence is desirable in order to disperse carbon-dioxide to bring in plank tonic food and oxygen.

A moderate fall out of fine sediments from the water can be tolerated because corals have self-cleansing mechanisms but burial beneath sediment for lengths of time could result in an asphyxiation and death. The polyp sack like body had an internal cavity which acted as its stomach. There was only a single opening to the outside, surrounded by tentacles. The polyp sat in a cup like depression on to pot its calcareous skeleton, or corallites, which is built upwards to form a support as it grew. Coral is classified according to this internal structure, which cannot often be observed directly.

3 Field works

3.1 Scope of the ground investigations

The ground investigation site works were carried out between 12 April 2025 and 24 April 2025. The field investigation consisted of advancing three boreholes (BH-01 to BH-03) in accordance with BS 5930:2015. The boreholes were drilled to encounter the rock level, which was found at approximately 13.70 m at BH-01, 15.15 m at BH-02, and 15.80 m at BH-03. Standard Penetration Tests (SPT) were conducted at 1.0 m intervals up to a depth of 10 m and at 1.5 m intervals beyond 10 m depth. In addition to the SPTs, disturbed soil samples were collected to determine the subsurface soil profile.



Figure 2: Conducting the investigation

3.2 Rotary Borehole

The boreholes were advanced by means of rotary drilling machine, the drilling was carried out with overburden cutting tools, and the dry cutting process was adopted to remove the cuttings from the bottom of the borehole. During the drilling operation the walls of the boreholes were supported by 76 mm dia. NX type flush coupling casings.

Table 1: Summary of boreholes depths

Borehole No.	Ground Water Level (m)	Overburden /Soil Drilling /Boulders (m)	Rock level (m)	Rock Drilling (m)	Total Depth (m)
BH-01	1.60	13.70	13.70 m from EGL	1.50	15.20
BH-02	1.50	15.15	15.15 m from EGL	0	15.15
BH-03	1.60	15.80	15.80 m from EGL	3.0	18.80

3.3 In-situ Testing

3.3.1 Standard Penetration Test

In this investigation, the Standard Penetration Test (SPT) was carried out at 1.5 m intervals in the overburden, except for the first 3 m, where it was conducted at 1 m intervals. The performance of this test is based on the test method specified in BS 1377. Disturbed samples of soil were collected from SPT tube.

SPT sampler (Split spoon sampler) inserted into the boring and it has been connected via steel rods to 63.5kg hammer.

Using automatic safety mechanism, hammer was raised a distance of 760mm and allowed it to fall freely and the energy drives the sampler in to the bottom of the boring. The process was repeated until the sampler penetrated 450mm. The numbers of blows were recorded for first 150mm (Seating drive) and then two consecutive 150mm intervals (Test drives).

The N value was computed by summing the blow counts for the two 150mm test drives. The blow count for the first 150mm is retained for reference purposes but not used to compute N value because the bottom of the boring is likely to be disturbed by drilling process and may be filled with loose soil that fell from the side of the boring.

The SPT samples were extracted from the sampler and saved the obtained soil samples in appropriate manners.

3.4 Laboratory Tests

Laboratory investigations were taken place in order to the sub surface assessment in geotechnical investigation. Detailed results of the laboratory investigation are given in appendix C.

3.4.1 Tests on Soil Samples

- Particle Size Distribution
- Specific gravity
- Direct shear
- Specific Gravity
- Natural Moisture Content

4 Factual Information

This Chapter presents the data obtained from the intrusive ground investigation and the results from laboratory testing.

4.1 Subsurface conditions

The sub surface conditions encountered at the site are graphically presented in the borehole logs attached in Appendix B. The soil horizons identified at the borehole locations are inferred from the samples taken from the borehole location. Soil horizons/layers generally represent a transition from one soil type to another and should not be assumed to represent an exact plane of geological change.

4.1.1 Coral Sand

According to the SPT values of the borehole samples, the predominant subsurface condition consists of medium-dense sand with silt and coral rock fragments, with SPT values ranging from 10 to 30. In BH-01, a loose layer was encountered between 3.00 m and 4.00 m depth, with an SPT value of less than 10. A similar loose layer was observed within the first 2.00 m in BH-02 and within the first 3.00 m in BH-03. A very dense coral sand layer was only encountered between 5.00 m and 6.00 m in BH-01.

4.1.2 Coral Rock

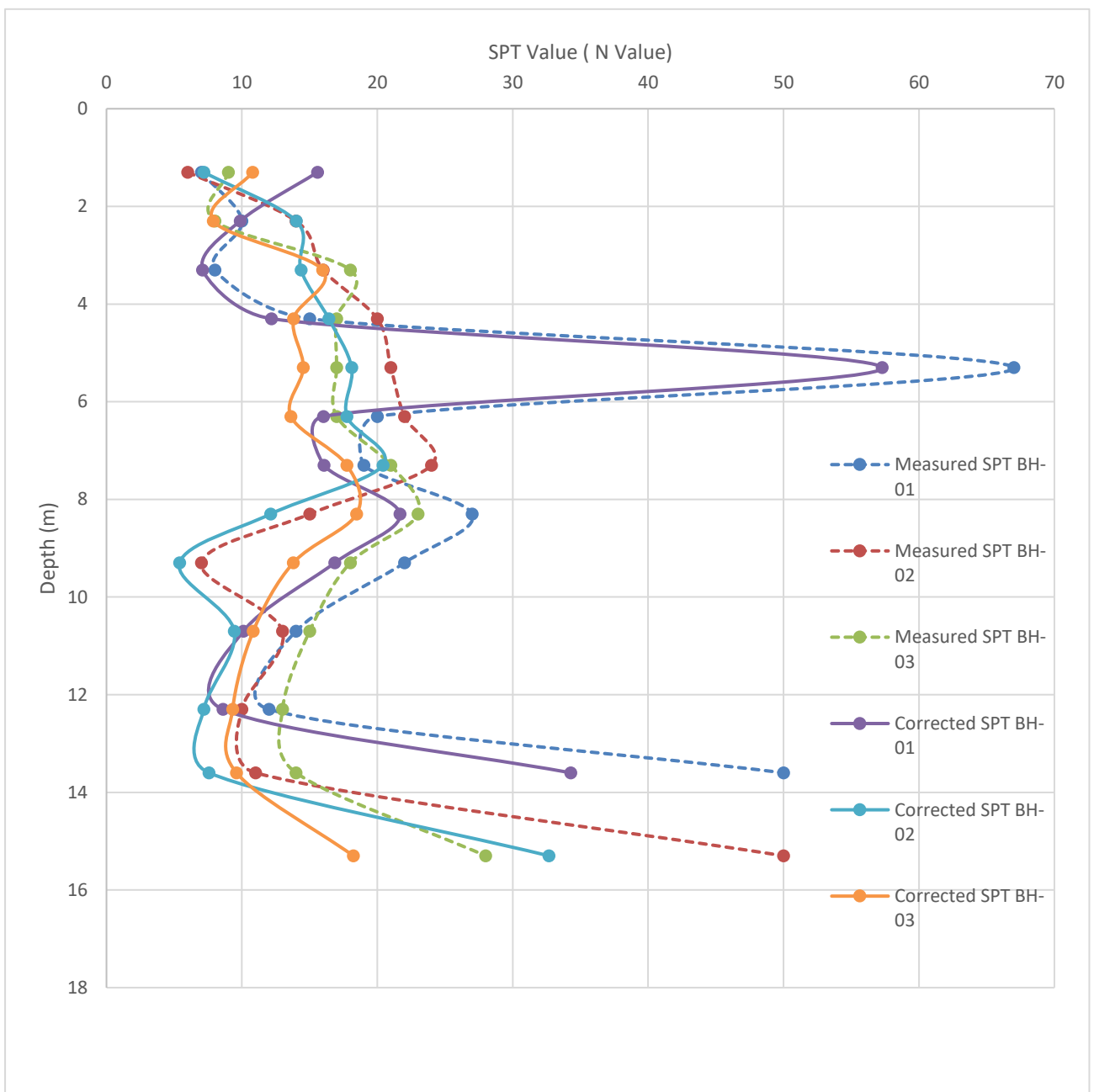
"According to the core recovery and RQD values, the predominant rock type is highly fractured, porous coral rock. Rock drilling was carried out in BH-01 and BH-03, while the rock level in BH-02 was identified through SPT testing. The rock level was encountered at 13.70 m, 15.15 m, and 15.80 m in BH-01, BH-02, and BH-03, respectively.

4.1.3 Classification

4.1.4 Strength

Standard Penetration Tests (SPT)

The corrected SPT-N values(N70) for the borehole are recorded as below figure 3.



4.2 Ground Water

The details of depths of drilling with ground water fluctuation at the time of drilling are indicated below. The ground water level was approximately between 1.50 m to 1.60 m from existing ground level at the time of investigation.

Figure 3:Corrected SPT comparison

5 Engineering Assessment

5.1 SOIL PROPERTIES

5.1.1 Soil strength and compressibility parameters

The energy method of SPT correction (Bowles, 1996) was used to estimate the soil strength parameters of the soil layers. The energy method of SPT correction uses the following relationship to determine the N'_{70} from the field SPT blow counts (N_{Field}):

$$N'_{70} = N_{\text{Field}} C_N \eta_1 \eta_2 \eta_3 \eta_4$$

Where

$$C_N = \sqrt{\frac{95.76}{p'_o}}$$

$$\eta_1 = \frac{E_r}{70}$$

p'_o = Effective overburden pressure at the test level

E_r = Efficiency of the hammer used (taken as 55%)

η_i = Modification factors (Bowles, 1996)

The estimated N'_{70} together with the particle size could be used to estimate the soil strength parameters at respective depths. The estimated soil strength parameters are drained (with drainage) parameters for sand and undrained (without drainage) parameters for clay.

From the results of the investigation, following main soil layers and subsoil layers may be identified. The thickness of these layers at the locations of the boreholes with the average SPT blow counts are given in Tables 1. Pl. note that sub-categories *a*, *b*, *c*, *d*, *e* and *f* are used for very soft, soft, firm, stiff, very stiff and hard cohesive soils and sub-categories *a*, *b*, *c*, *d*, and *e* are used for very loose, loose, medium dense, dense and very dense cohesion less soils.

Layer 1-	Fine to medium, angular to sub rounded silty CORAL SAND/ Fine to medium, angular to sub rounded CORAL SAND with some silt/ Fine to coarse, angular to sub rounded CORAL SAND/ Fine to coarse, angular to sub-rounded CORAL SAND with some silt and coral rock./ Fine to coarse, angular to sub rounded CORAL SAND with some silt and coral rock fragment
Layer 1b -	Loose
Layer 1b/1c -	Loose to medium dense
Layer 1c -	Medium dense
Layer 1c/1d -	Medium dense to dense
Layer 1e -	Very dense

Thickness of the different layers at the borehole locations are given in Table 2.

Table 2: Thickness of the different layers at the borehole locations and the observed SPT

BH-01			BH-02		
Layer	Thickness (m)	SPT	Layer	Thickness (m)	SPT
Layer 1c	2.00	13	Layer 1b	2.00	06
Layer 1b/1c	2.00	08 – 10	Layer 1c	3.00	14 – 20
Layer 1c	1.00	15	Layer 1c/1d	3.00	21 – 24
Layer 1e	1.00	67	Layer 1c	1.00	15
Layer 1c	2.00	19 – 20	Layer 1b/1c	1.50	07
Layer 1c/1d	2.00	22 – 27	Layer 1c	1.50	13
Layer 1c	2.00	14	Layer 1b/1c	3.00	10 – 11
Layer 1b/1c	1.70	12	Layer 1e	0.15	>50

BH-03		
Layer	Thickness (m)	SPT
Layer 1b/1c	3.00	08 – 09
Layer 1c	4.00	17 – 18
Layer 1c/1d	2.00	21 – 23
Layer 1c	6.00	13 – 18
Layer 1c/1d	0.80	28

The compressibility properties of different soil layers were estimated based on the SPT blow counts and the estimated shear strength parameters. The estimated shear strength parameters and the compressibility properties given in Table 3 were used in giving the recommendations. Laboratory consolidation tests were not done on undisturbed samples obtained from cohesive soil layers, and hence consolidation properties of those layers were assumed based on the past experience and SHANSEP procedure. The consolidation properties given in Table 3 were used in giving the recommendations.

Table 3: Estimated strength parameters and compressibility properties of Layers

Layer	ϕ /	c / (kPa)	c_u (kPa)	$\frac{C_c}{1 + e_o}$	OCR	Elastic modulus, E (kPa)	Poisson's ratio, ν
Layer 1b	26	3	-	-	-	10500	0.33
Layer 1b/1c	25 – 28	3	-	-	-	11000 – 13500	0.32
Layer 1c	28 – 32	3	-	-	-	14000 – 17500	0.30
Layer 1c/1d	32 – 33	3	-	-	-	18000 – 21500	0.29
Layer 1e	40	3	-	-	-	41000	0.25

Static ground water table is present at about 1.50 m to 1.60 m below the ground surface at the time of investigation.

5.1.2 Condition of the bedrock

The bedrock level varies from 13.70 m to 15.80m within the investigated bore holes. In BH 01, and BH 03, the bedrock consisting of coral reef was encountered at a depth of 13.70 m, 15.15 m and 15.80 m respectively. The coral reef was cored only at BH 01 and BH 03 and the cores obtained from the investigation are classified according to the classification system given in Table 4. The approximate rock mass rating (RMR) was also estimated using the borehole logs and the approximate grade of rock together with the RMR was used to give recommendations regarding the carrying capacity of piles in the bedrock.

Table 4: Rock classification system used

Grade	Description	Lithology
Grade I	Fresh rock	Clean rock
Grade II	Slightly weathered rock	Increased fractures
Grade III	Moderately weathered rock	Partly changed to soil; rock > soil
Grade IV	Highly weathered rock	Partly changed to soil; rock < soil
Grade V	Completely weathered rock	Some remnant rock structure; completely weathered to soil

Table 5: Quality of bedrock

BH 01					
Depth (m)		CR (%)	RQD (%)	UCS (N/mm ²)	Grade
From	To				
13.70	15.20	26	0	-	Grade V
BH 03					
Depth (m)		CR (%)	RQD (%)	UCS (N/mm ²)	Grade
From	To				
15.80	17.30	63	0	-	Grade V
17.30	18.80	33	0	-	Grade V

6 FOUNDATION RECOMMENDATIONS

6.1 Shallow foundation

The proposed structure is a central cold chain facility building. The allowable bearing capacities of the shallow foundations against compressive forces are estimated based on the shear failure and settlement considerations.

6.1.1 Shear Failure of Soil under compressive forces

The ultimate carrying capacity (q_{ult}) of shallow foundations on sand is estimated using the Hansen bearing capacity equation (Bowles, 1996) assuming general shear failure and vertical applied load.

6.1.2 Estimation of Settlement of Shallow Foundations

The immediate settlement of the subsurface due to the applied load was estimated using the method proposed by Schemertmann (1978) and the consolidation settlement is estimated using Terzaghi's 1D consolidation theory. The elastic modulus values were estimated using the commonly available empirical correlations with SPT N values.

Parry (1970) method can also be used to estimate the settlement of shallow foundations directly using the field SPT values.

The allowable carrying capacities given in this report are estimated based on the following assumptions:

- The clear distance between any two adjacent footings is more than the width of the larger footing.
 - No lateral forces and the moments are acting on the foundations, and the ground surface is horizontal upto a distance of at least 3 times foundation width from the edge of individual footings and combined footings, and 5m from the edge of all the raft foundations.
 - Coral sand and the coral reef (rocks) have the elastic modules equal to 0.90 of that of corresponding mineral soils or rocks.
-

-
- As any lab tests are not done on any undisturbed samples, compressibility and consolidation properties given in Table 2 are applicable to corresponding layers; and
 - The subsurface profile within the site is represented by the reported borehole investigation results.

6.1.3 Ground improvement using replacement

Layer 1b/1c is present at BH 1 and the associated areas or any other shallow weak soil layer (for e.g. uncontrolled fill layers etc.) under the foundation should be replaced upto about 3.5m below the ground surface by the replacement process given below or any other equivalent method suitable for site conditions may be adopted.

It should be noted here that dewatering, excavation of the raft foundation and soil compaction near existing nearby structures may cause settlement.

- i. Installation of the designed shoring system for the excavation upto the required level.
- ii. Removal of the soil upto the required depth.
- iii. Dewater the excavation below 300mm from the top level of the excavation already made and compact the bottom of the excavation with a wacker compactor.
- iv. Fill the balanced excavation upto the raft bottom in layers not exceeding 300mm thickness compacted to achieve 95% degree of compaction upto the foundation level.

The thickness of ground improvement process described above may vary across the site and the replacement of the weak soil layers should be carried out under the supervision of a qualified person with experienced in the relevant areas. Appropriate quality control procedures should be followed to ensure the quality of the replacement process.

6.1.4 Allowable carrying capacities of raft foundation

Allowable carrying capacity of a raft foundation placed at 3 m depth below the existing ground surface level is recommended on a compacted fill recommended in section 6.1.3 for a 25m x 25m raft as 120 kPa for allowable settlement of 90mm subjected to the applicable assumptions to the raft foundations made in section 6.1.2. The floating effect is considered as 0.75 times raft bottom effective overburden pressure. The total carrying capacity of the raft is 150.0 kPa.

6.1.5 Modulus of sub grade reactions for raft foundation

Modulus of sub grade reactions for a raft foundation placed at 3 m depth below the existing ground surface level as 1860 kN/m³ after the 50 years from beginning of the construction and 2450 kN/m³ until within first one year from beginning of the construction.

6.2 Deep foundation

Rock socketed bored and cast in-situ piles may also be used to support the proposed structures. The allowable skin friction and the end bearing capacities of the soil layers are given below.

6.2.1 Skin friction

The estimated ultimate skin friction of the soil and rock layers are given in Table 6. Layer thicknesses at the borehole locations shall be taken from Table 2.

Table 6: Estimated ultimate skin friction of soil and rock layers

Layer	Ultimate skin friction (kPa)
Layer 1b	05
Layer 1b/1c	05
Layer 1c	05
Layer 1c/1d	10
Layer 1e	25

Grade V	50
---------	----

6.2.2 End bearing

The top level of the bedrock is in a highly weathered state at the borehole locations, and the slope of the top of the bedrock may be mildly steep as it varies from about 13.70 m to 15.80 m across the three boreholes. Therefore, allowable end bearing capacity of a pile socketed 1m or one pile diameter, whichever is higher, into the bedrock shall be recommended as given in Table 7.

Table 7: Allowable end bearing capacities of rock as given in Table 5

Grade of rock	Allowable carrying capacity (kPa)
Grade V	800

7 SUMMARY OF RECOMMENDATIONS

Only a summary of the recommendations are given in this section and the readers are recommended to go through the entire report.

- As any lab tests are not done on any undisturbed samples, the soil strength parameters given in Table 2, based on the experience of the undersigned, shall be recommended for the soil layers at different depths for the layers identified in Table 1.
 - The floating effect is considered as 0.75 times raft bottom effective overburden pressure.
 - Allowable carrying capacity of a raft foundation placed at 3 m depth below the existing ground surface level is recommended on a compacted fill recommended in section 6.1.3 for a 25m x 25m as 150 kPa for allowable settlement of 90mm subjected to the applicable assumptions to the raft foundations made in section 6.1.2.
 - Coral sand and the coral reef (rocks) have the elastic modules equal to 0.90 of that of corresponding mineral soils or rocks.
-

-
- It is highlighted here that the effect of the construction methods or loading of the foundations on the adjacent structures should be given due consideration. In this case the main considerations are:
 - Washing off the fines under existing foundations during excavation and dewatering. The water table is at about 1.50 m to 1.60 m below the ground surface but temporary rising of the water table during rain may happen.
 - Settlement of the adjacent structures due to excavation and compaction very close to them during construction or during installation of the foundations; and
 - Settlement of the adjacent structures due to loading due to the proposed structure, if the proposed structure is placed very close to the adjacent structures on shallow foundations.
 - The deep foundation recommendations are also given in section 6.2.

Foundation Recommendation Given By:



.....

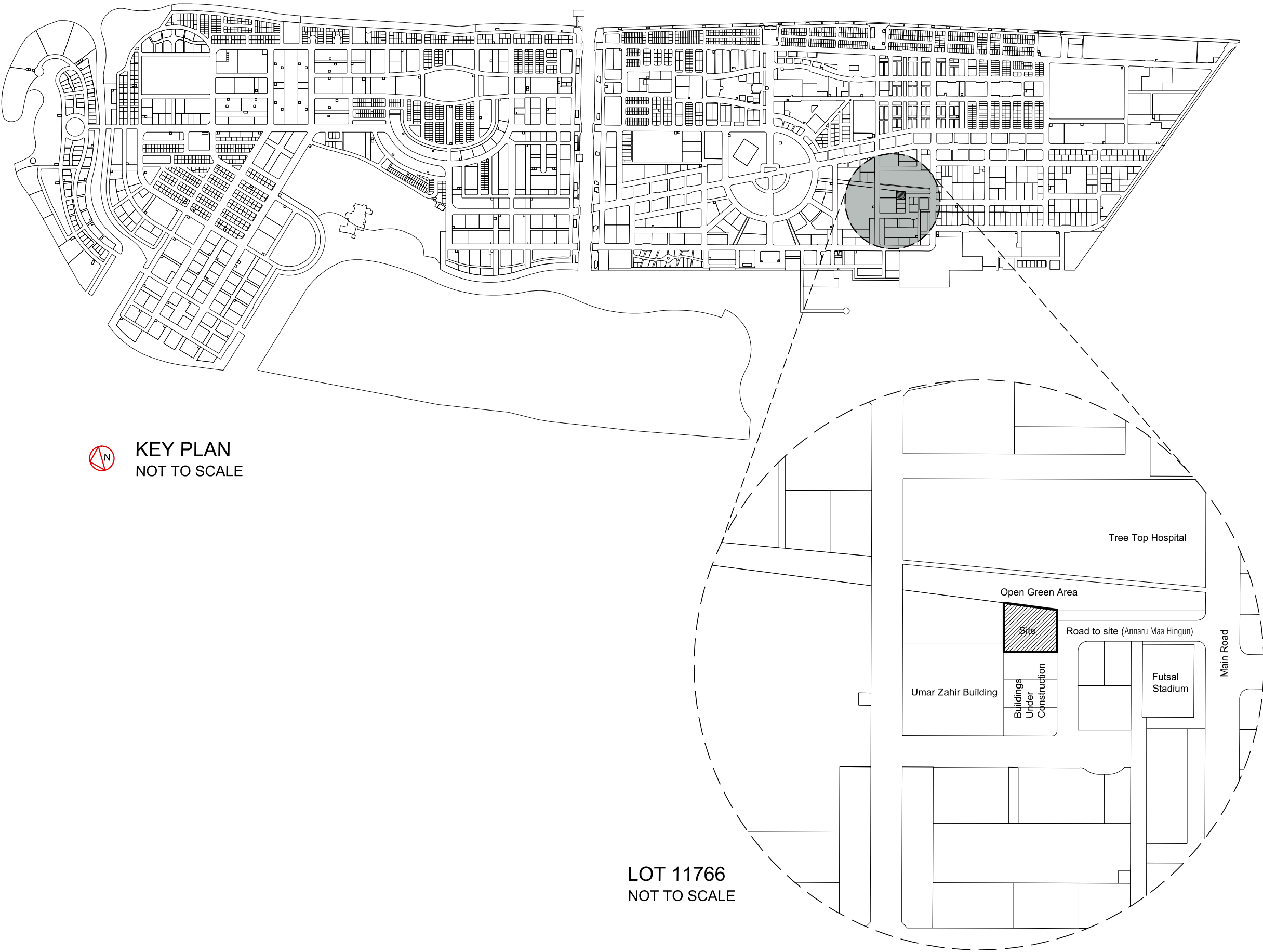
Prof. H. S. Thilakasiri,

PhD, C. Eng., FIE(SL)

Geotechnical Engineering Consultant

H. S. THILAKASIRI, C.Eng., Int. PEng (SL), FIE (SL)
PROFESSOR OF CIVIL ENGINEERING & CHARTERED ENGINEER
DEPARTMENT OF CIVIL ENGINEERING,
SRI LANKA INSTITUTE OF INFORMATION TECHNOLOGY

Appendix A: Site Map



PROJECT TITLE :

CONSULTANCY FOR DESIGNING & SUPERVISION OF THE CENTRAL COLD CHAIN FACILITY WITH CLIMATE -FRIENDLY DESIGNS AT HULHUMALE

CLIENT :

MINISTRY OF HEALTH, REPUBLIC OF MALDIVES

DRAWING TITLE :

LOCATION PLAN

DRAWN BY- RAKSHITHA PERERA

CHECKED BY- AR. ASHANI MIRANDA

SCALE
NTS

DATE
17.02.2025

DRAWING NO :

MOH/ MALDIVES/ AR/ CD/ 00

REV.	DATE.	DESCRIPTION

INTERNATIONAL LEAD CONSULTANTS :

NAME: CHANDANA EDIRISURIYA

DESIGNATION: DEPUTY TEAM LEADER/ SENIOR ARCHITECT

SIGNATURE: _____

NAME: NANDANA ABEYSURIYA

DESIGNATION: SENIOR STRUCTURAL ENGINEER

SIGNATURE: _____

NAME: SHIRAN JAYALATH

DESIGNATION: MEP ENGINEER

SIGNATURE: _____

NATIONAL SUB CONSULTANTS :

NAME: ABDUL THALAAL AHMED

DESIGNATION: ARCHITECT

SIGNATURE: _____

NAME: KINNANATH HUSSAIN

DESIGNATION: STRUCTURAL ENGINEER

SIGNATURE: _____

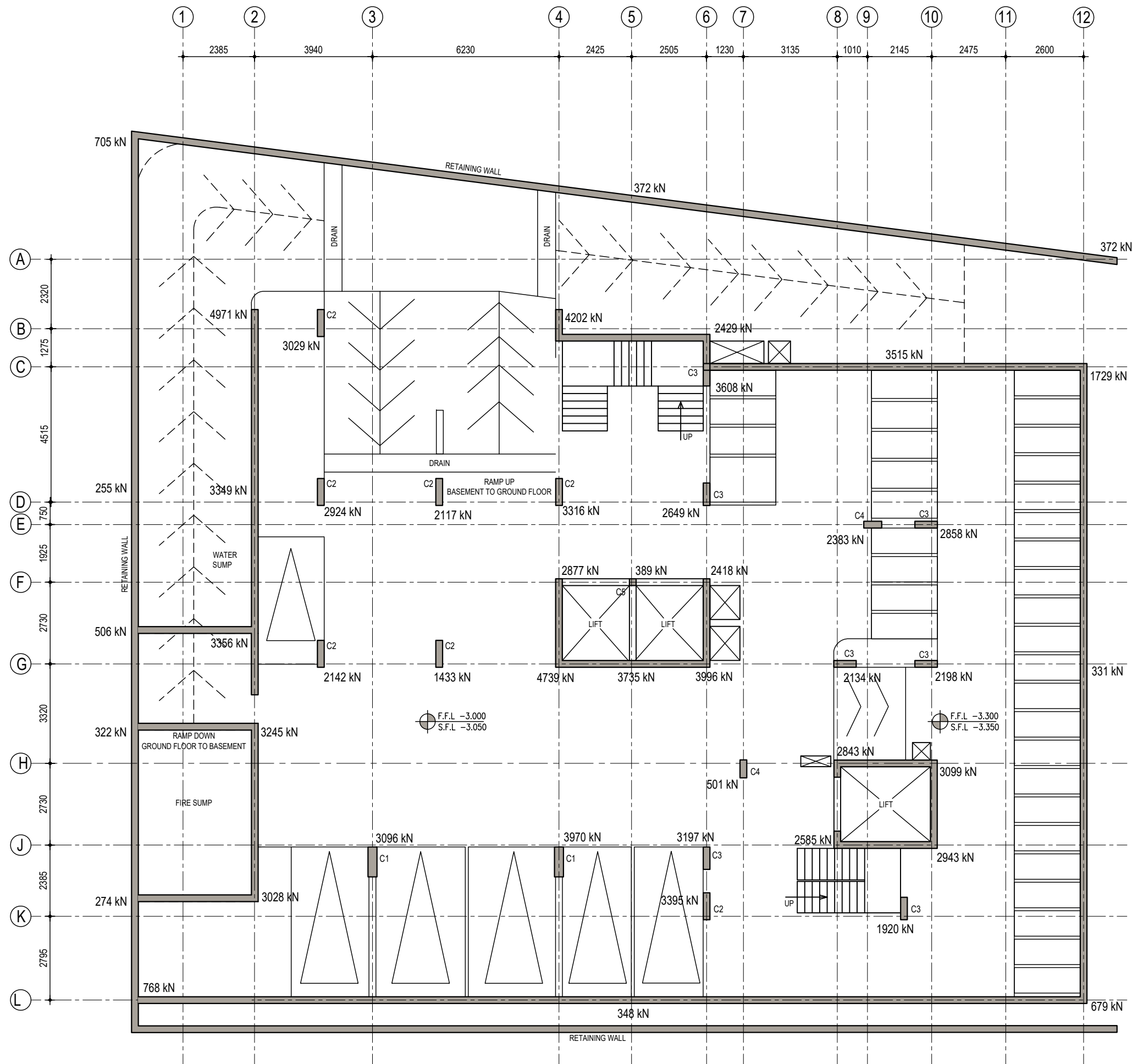
NATIONAL SUB CONSULTANTS :

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Meheli Goalhi
Malé 20012
Republic of Maldives
Tel: 960 3318452
E-Mail: admin@gedor.com.mv
Webpage: gedor.com.mv

GEDOR CONSULTING PVT. LTD.

LEAD CONSULTANTS :

DESIGN LINK ASSOCIATES (PVT) LTD.
CHARTERED ARCHITECTS, ENGINEERS, INTERIOR DESIGNERS,
AND LANDSCAPE DESIGNERS
NO 1-1/1, STARTFORD TERRACE, COLOMBO 06.
TEL: 011 5336509, 011 5336517
EMAIL: designlink50@gmail.com



Appendix B: Borehole Log

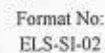
		ELS INTERNATIONAL (PVT) LTD. GEOTECHNICAL INVESTIGATIONS DIVISION						Format No: ELS-SI-02	
Project		GEOTECHNICAL INVESTIGATION FOR THE PROPOSED CENTRAL COLD CHAIN FACILITY WITH CLIMATE-FRIENDLY DESIGNS AT HULHUMALE						Borehole No	
Client		Design Link Associates (pvt) Ltd						BH-01	
Location		Hulhumale	Rig	Track Drill	Core Diameter	54mm	Ground Water Level		1.60 m
Date of Started		12.04.2025	Drilling Method	Rotary	Casing depth	13.70 m	Coordinates		E -337814.55
Date of Finished		17.04.2025	Casing Diameter	76mm	Elevation (m)	-			N-465810.60

Depth (m)	Sa. Cond	Sa. NO.	Sa. Type	Reduced level	Depth (m)	Legend	Soil Description	Field Records (SPT)				SPT Resistance - Blows/ft									
								15cm	15cm	15cm	N										
												5	10	15	20	25	30	35	40	45	
0.00					0.00		Ground level														
1.00		D1	DS				Medium dense, offwhite to light gray, fine to medium, angular to sub rounded silty CORAL SAND.	9	9	4	13	13									
2.00		D2	SS		1.60			2	3	7	10	10									
3.00		D3	SS					7	3	5	8	8									
4.00		D4	SS		3.00		Loose, offwhite to light gray, fine to medium, angular to sub rounded silty CORAL SAND.	9	4	11	15	15									
5.00		D5	SS		4.00		Medium dense, offwhite to light gray, fine to medium, angular to sub rounded CORAL SAND with some silt.	23	22	45	67	>50									
6.00		D6	SS		5.00		Very dense, offwhite to light gray, fine to coarse, angular to sub rounded CORAL SAND.	16	10	10	20	20									
7.00		D7	SS		6.00		Medium Dense, offwhite to light gray, fine to coarse, angular to sub rounded CORAL SAND with some silt and coral rock. (The SPT sample encountered between 10.50 m and 13.50 m consists predominantly of coarse coral rock fragments.)	13	8	11	19	19									
8.00		D8	SS					12	15	12	27	27									
9.00		D9	SS					11	11	11	22	22									
10.00		D10	SS																		

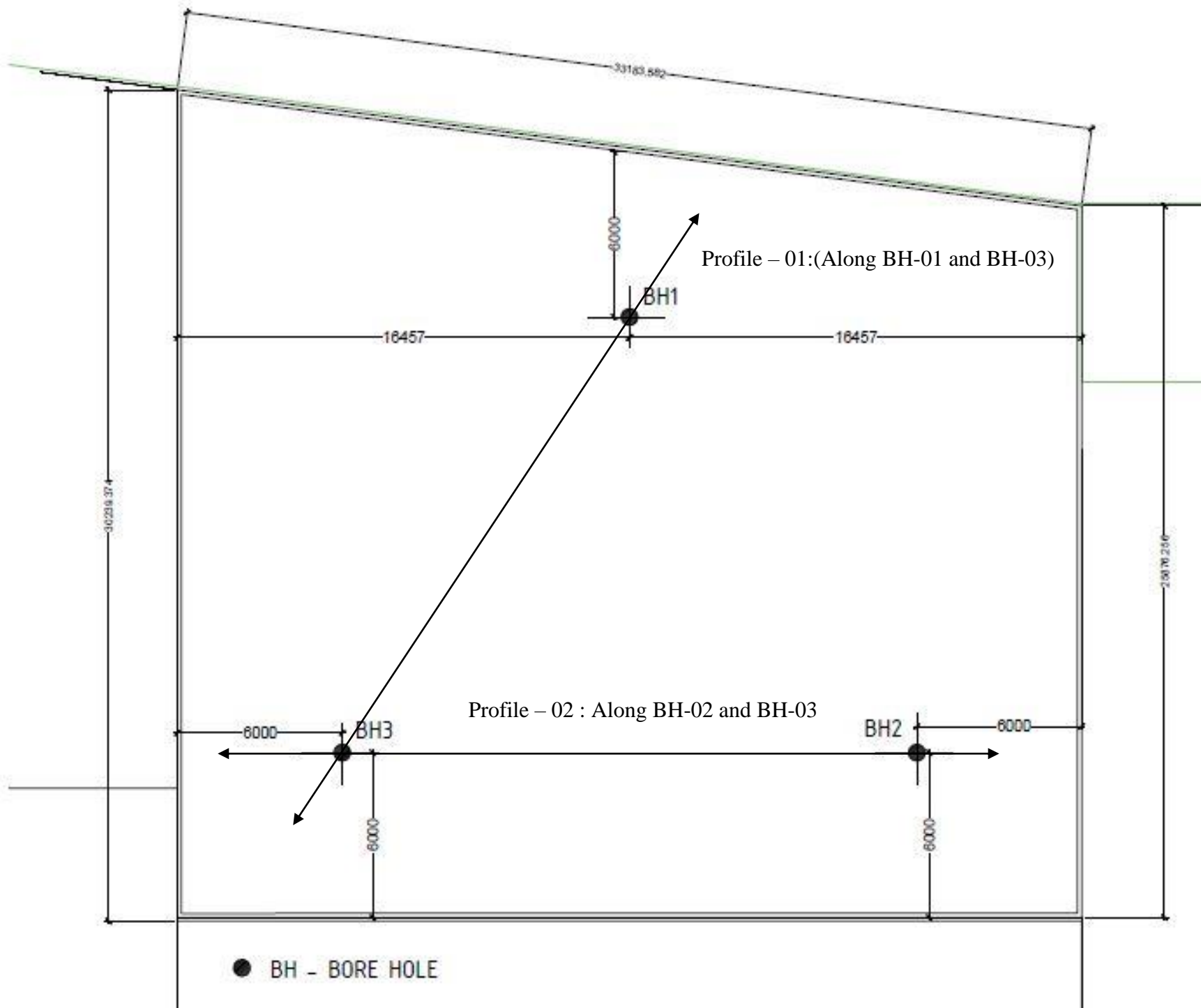
Sample Key / Test Key						Remarks	Logged By:
SPT	Where fall 0.3m penetration has not been achieved the number of blows for the quoted penetration is given (not N-value)	D - Disturbed Sample	N - Natural Moisture Content	C - Consolidation		Existing ground level considered as the zero level	Subash
GWL	Ground Water Level observed inside the Borehole, after the saturation	SS - SPT Sample	L - Atterberg Limit Test	UCT - Unconfined Compression			
NE	Not Encountered	W - Water Sample	G - Grain Size Analysis	CU - Consolidated Undrained			
HB	- Hammer Bounce	WS - Wgrey Sample	SG - Specific Gravity Test	UU - Unconsolidated Undrained			
FD	- Free Down	UD - Undisturbed Sample	B - Bulk Density	pH - Chemical			
		CS - Core Sample	V - Vane Shear Test	O - Organic content			
		Cr - Core Recovery (%)		SO ₄ ²⁻ - Sulphate Content			
		RQD - Rock Quality Designation (%)		Cl ⁻ - Chloride Content			
	Made Ground		Silt		Gravel		Laterite Nodules
	Clay		Sand		Organic Matter		Silty Sand
					Completely Weathered Rock		Highly Weathered Rock
							Fresh Rock



Sample Key / Test Key					Remarks	Logged By:
SPT	Where full 0.3m penetration has not been achieved the number of blows for the quoted penetration is given (not N-value)	D - Disturbed Sample SS - SPT Sample W - Water Sample	N - Natural Moisture Content L - Atterberg Limit Test G - Grain Size Analysis	C - Consolidation UCT-Unconfined Compression CU - Consolidated Undrained	Existing ground level considered as the zero level	Subash
GWL	Ground Water Level observed inside the Borehole, after the saturation	WS-Wgrey Sample UD- Undisturbed Sample	SG -Specific Gravity Test B - Bulk Density	UU-Unconsolidated Undrained pH - Chemical		Kasun Rangarath
NE	Not Encountered	CS- Core Sample	V - Vane Shear Test	O - Organic content		Drilled By:
HB	-Hammer Bounce	Cr - Core Recovery (%)		SO ₄ ²⁻ - Sulphate Content		A P Susantha
FD	- Free Down	RQD-Rock Quality Designation (%)		Cl - Chloride Content		
	Made Ground	Silt	Gravel	Laterite Nodules	Completely Weathered Rock	
	Clay	Sand	Organic Matter	Silty Sand	Highly Weathered Rock	Fresh Rock

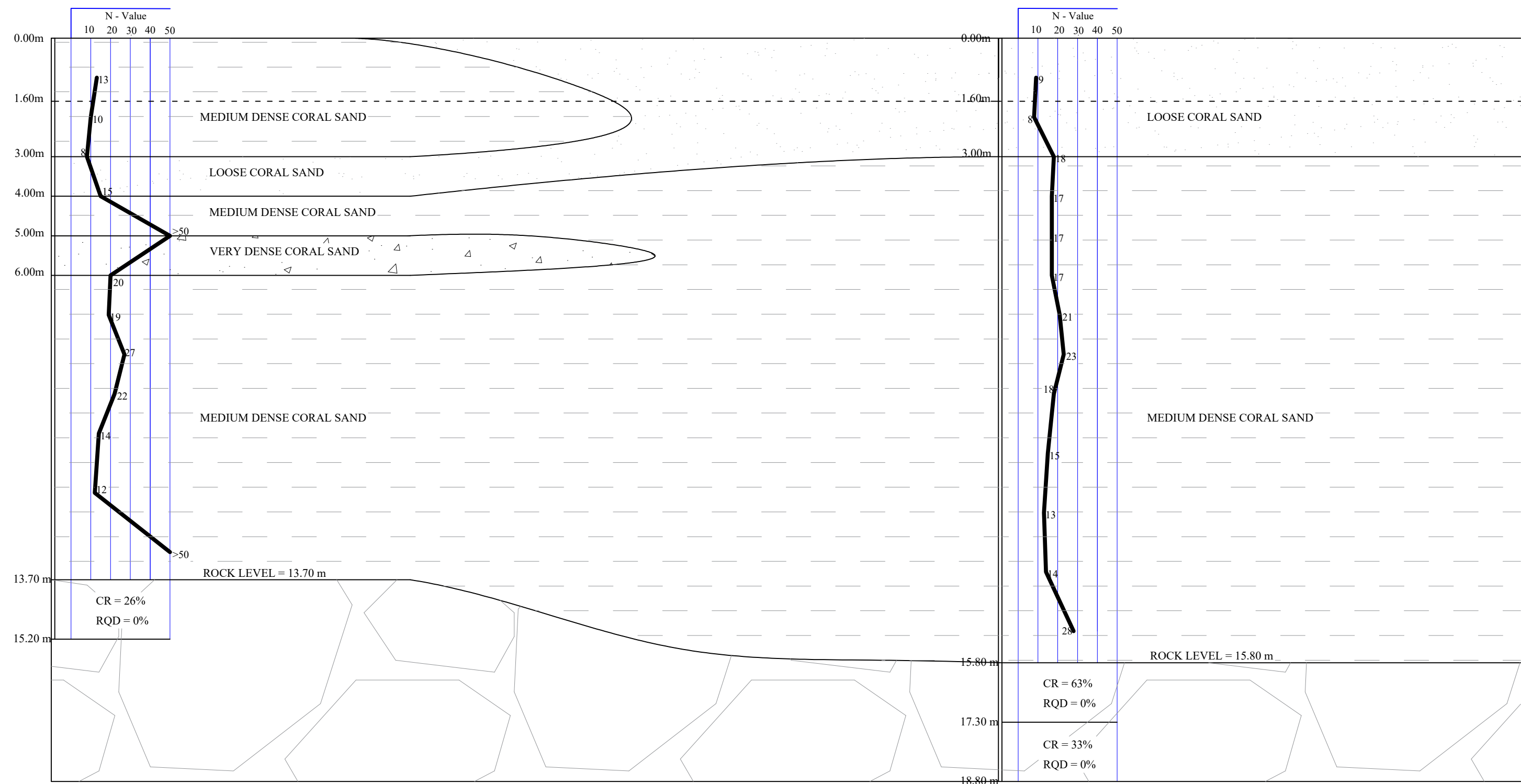


Project		GEOTECHNICAL INVESTIGATION FOR THE PROPOSED CENTRAL COLD CHAIN FACILITY WITH CLIMATE-FRIENDLY DESIGNS AT HULHUMALE					Borehole No		BH-03													
Client		Design Link Associates (pvt) Ltd					Sheet		2 of 2													
Location		Hulhumale		Rig	Track Drill	Core Diameter	54mm		Ground Water Level		1.60 m											
Date of Started		22.04.2025		Drilling Method	Rotary	Casing depth	15.80		Coordinates		E -337801.15 m											
Date of Finished		24.04.2025		Casing Diameter	76mm	Elevation (m)	-				N-465822.25 m											
Depth (m)	Sa. Cond	Sa. NO.	Sa. Type	Reduced level	Depth (m)	Legend	Soil Description	Field Records (SPT)														
								15cm	15cm	15cm	N	SPT Resistance - Blows/ft										
10.00							Continued from Page I					5	10	15	20	25	30	35	40	45		
11.00	D11		SS				Same as the above	7	8	7	15										15	
12.00	D12		SS					5	6	7	13											13
13.00	D13		SS					4	8	6	14											14
14.00	D14		SS					15	13	15	28											28
15.00							ROCK LEVEL = 15.80 m															
16.00	D15		CS		15.80		Moderately weathered and highly fractured light gray and offwhite, porous CORAL REEF	CR=63%		RQD = 0%												
17.00																						
18.00	D16		CS		17.30		Highly weathered and fractured light gray and offwhite, porous CORAL REEF	CR=33%		RQD = 0%												
19.00					18.80		The borehole was terminated at the depth of 18.80 m depth															
20.00																						
Sample Key / Test Key												Remarks		Logged By:								
SPT		Where full 0.3m penetration has not been achieved the number of blows for the quoted penetration is given (not N-value)			D - Disturbed Sample SS - SPT Sample W - Water Sample WS-Wgrey Sample UD- Undisturbed Sample CS- Core Sample Cr - Core Recovery (%) RQD-Rock Quality Designation (%)			N - Natural Moisture Content L - Amberg Limit Test G - Grain Size Analysis SG-Specific Gravity Test B - Bulk Density V - Vane Shear Test			C - Consolidation UCT-Unconfined Compression CU - Consolidated Undrained UU-Unconsolidated Undrained pH - Chemical O - Organic content SO ₄ ²⁻ - Sulphate Content Cl - Chloride Content			Existing ground level considered as the zero level		Subash						
GWL		Ground Water Level observed inside the Borehole, after the saturation														Supervised By:						
NE		Not Encountered														Kasun Ranganath						
HB		Hammer Bounce														Drilled By:						
FD		Free Down														AP Susantha						
		Made Ground					Silt			Gravel			Laterite Nodules			Completely Weathered Rock			Fresh Rock			
		Clay					Sand			Organic Matter			Silty Sand			Highly Weathered Rock						



BH - 01

BH - 03



NOTES: Profile is plotted only according to the data obtained from the borehole locations and actual soil profile may vary from this profile

Project: Geo-technical Investigation For The Proposed Cetral Cold Chain Facility With Climate-friendly Designs At Hulhumale.

PROFILE : Subsurface Profile along BH-01 and BH-03

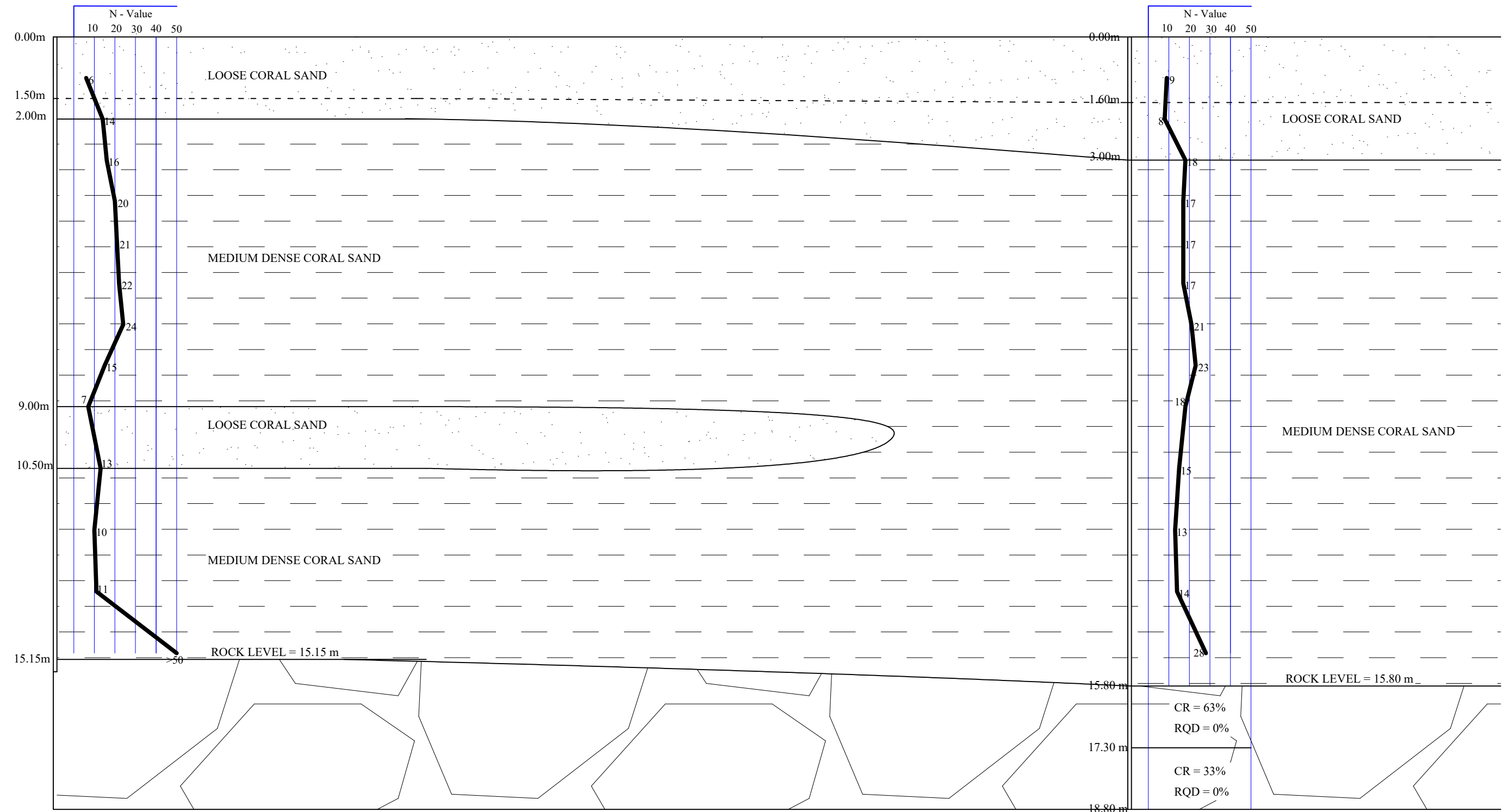
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PAGE : 01



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BH - 02

BH - 03



NOTES: Profile is plotted only according to the data obtained from the borehole locations and actual soil profile may vary from this profile

Project: Geo-technical Investigation For The Proposed Cetral Cold Chain Facility With Climate-friendly Designs At Hulhumale.


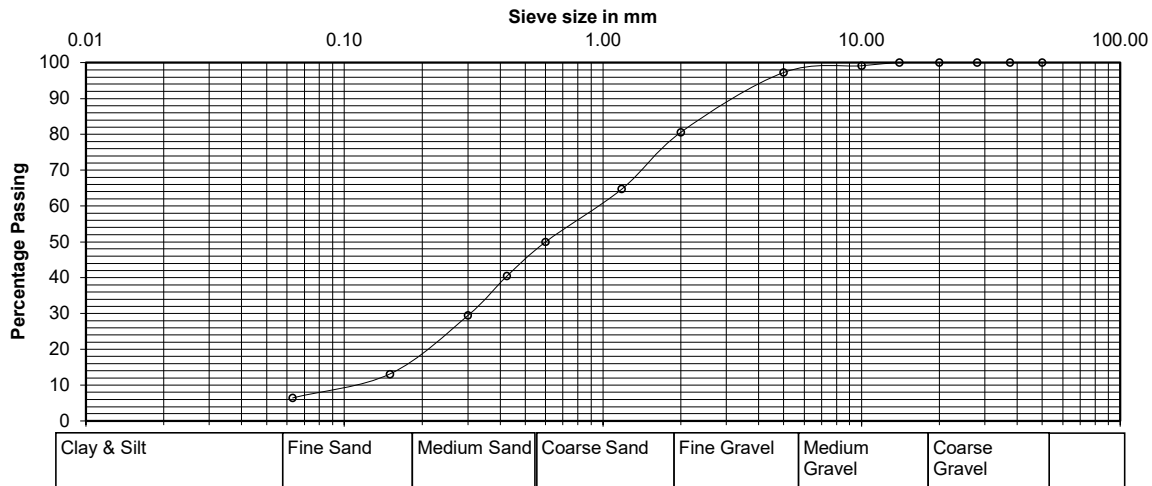


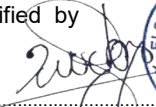
PROFILE : Subsurface Profile along BH-02 and BH-03

SCALE : Vertical - 1:10 and Horizontal - 1:8
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ELS International (Pvt) Ltd

Appendix C: Laboratory Test Results

	PARTICLE SIZE ANALYSIS OF SOILS TEST METHOD - BS 1377: PART 2			Test Format No:	ELS-INT-S-01
				Revision No:	00
Project data:					
*Project	GEOTECHNICAL INVESTIGATION FOR THE PROPOSED CENTRAL COLD CHAIN FACILITY WITH CLIMATE-FRIENDLY DESIGNS AT HULHUMALE				
*Client:	Design Link Associates (pvt) Ltd				
* Consultant:	-				
*Contractor:	-				
Sample data:					
*Sampling Location:	BH-02	*Depth:	3.00 - 3.45	Lab Ref. NO.	OVE/317/S/01
*Sample Description:	Silty SAND - Poorly graded (SPM)			Date of Test:	24.04.2025
Test Method:	Washing and Sieving			Date of Report:	25.04.2025
Test data:					
Sieve Size (mm)	Weight of Retained (g)	Retained (%)	Cum. Retained (%)	Passing Percentage (%)	
50.00	0.0	0.00	0.00	100.00	Weight of dry Sample(g) (Before Washed) 272.60
37.50	0.0	0.00	0.00	100.00	
28.00	0.0	0.00	0.00	100.00	Weight of dry Sample(g) (After Washed) 255.90
20.00	0.0	0.00	0.00	100.00	
14.00	0.0	0.00	0.00	100.00	
10.00	2.3	0.84	0.84	99.16	
5.00	5.1	1.87	2.71	97.29	
2.00	45.6	16.73	19.44	80.56	
1.18	43.2	15.85	35.29	64.71	
0.600	40.1	14.71	50.00	50.00	SILT % (<0.06 mm) 6.23
0.425	26.0	9.54	59.54	40.46	SAND % (0.06 - 2 mm) 74.33
0.300	30.1	11.04	70.58	29.42	Gravel (> 2 mm) 19.44
0.150	44.5	16.32	86.90	13.10	
0.063	18.1	6.64	93.54	6.46	
Pan	0.2				
Total	255.2				
					
<p>Comment: "" As stated by the client. This report refers specially to the sample analyzed. This report shall not be reproduced except in full, without the written approval of ELS Laboratory.</p>					
Tested by		Checked by		Certified by	
					


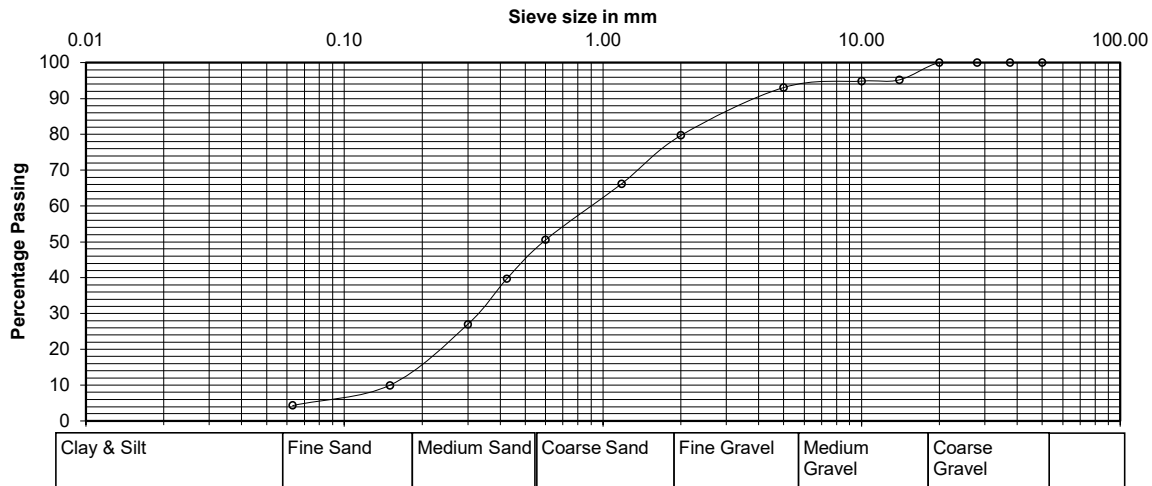


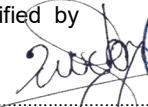
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Tel: 0094 011 2 517037 / 517365/ Fax: 0094112509806 E mail. els@lanka.com.lk

	PARTICLE SIZE ANALYSIS OF SOILS TEST METHOD - BS 1377: PART 2		Test Format No:	ELS-INT-S-01	
			Revision No:	00	
Project data:					
*Project	GEOTECHNICAL INVESTIGATION FOR THE PROPOSED CENTRAL COLD CHAIN FACILITY WITH CLIMATE-FRIENDLY DESIGNS AT HULHUMALE				
*Client:	Design Link Associates (pvt) Ltd				
* Consultant:	-				
*Contractor:	-				
Sample data:					
*Sampling Location:	BH-03	*Depth:	3.00 - 3.45	Lab Ref. NO.	OVEI/317/S/01
*Sample Description:	Slightly Silty SAND - Poorly graded - Gap Graded (SPg)			Date of Test:	24.04.2025
Test Method:	Washing and Sieving			Date of Report:	25.04.2025
Test data:					
Sieve Size (mm)	Weight of Retained (g)	Retained (%)	Cum. Retained (%)	Passing Percentage (%)	
50.00	0.0	0.00	0.00	100.00	Weight of dry Sample(g) (Before Washed) 334.30
37.50	0.0	0.00	0.00	100.00	
28.00	0.0	0.00	0.00	100.00	Weight of dry Sample(g) (After Washed) 320.40
20.00	0.0	0.00	0.00	100.00	
14.00	16.1	4.82	4.82	95.18	
10.00	1.1	0.33	5.15	94.85	
5.00	5.9	1.76	6.91	93.09	
2.00	44.8	13.40	20.31	79.69	
1.18	45.0	13.46	33.77	66.23	
0.600	52.3	15.64	49.42	50.58	SILT % (<0.06 mm) 4.14
0.425	36.3	10.86	60.28	39.72	SAND % (0.06 - 2 mm) 75.55
0.300	42.6	12.74	73.02	26.98	Gravel (> 2 mm) 20.31
0.150	56.8	16.99	90.01	9.99	
0.063	18.9	5.65	95.66	4.34	
Pan	0.3				
Total	320.1				
					
Comment: "" As stated by the client. This report refers specially to the sample analyzed. This report shall not be reproduced except in full, without the written approval of ELS Laboratory.					
Tested by		Checked by		Certified by	
					


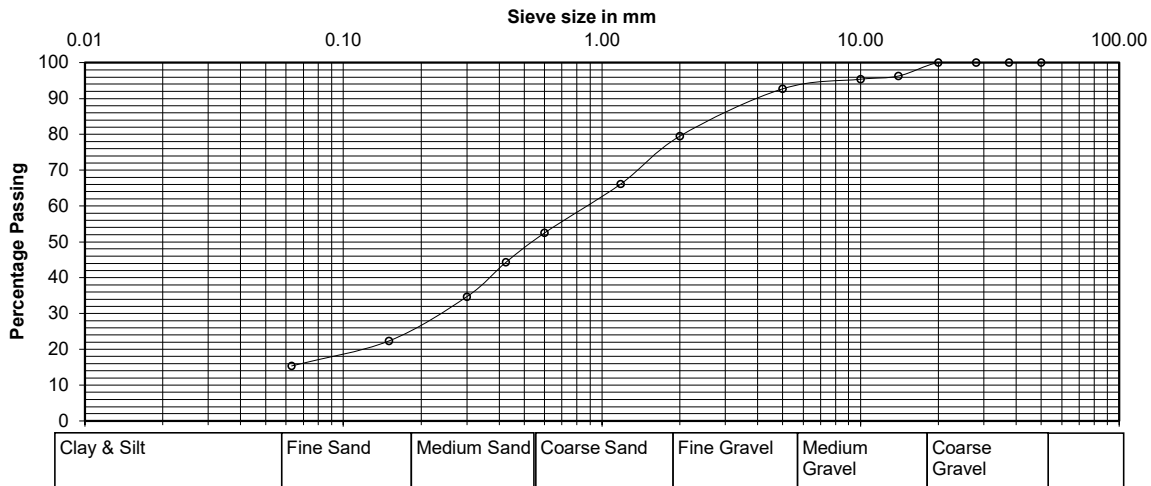


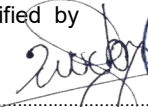
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	PARTICLE SIZE ANALYSIS OF SOILS TEST METHOD - BS 1377: PART 2			Test Format No:	ELS-INT-S-01
				Revision No:	00
Project data:					
*Project	GEOTECHNICAL INVESTIGATION FOR THE PROPOSED CENTRAL COLD CHAIN FACILITY WITH CLIMATE-FRIENDLY DESIGNS AT HULHUMALE				
*Client:	Design Link Associates (pvt) Ltd				
* Consultant:	-				
*Contractor:	-				
Sample data:					
*Sampling Location:	BH-03	*Depth:	3.00 - 3.45	Lab Ref. NO.	OVEI/317/S/01
*Sample Description:	Very Silty SAND - Non Plastic (SML)			Date of Test:	24.04.2025
Test Method:	Washing and Sieving			Date of Report:	25.04.2025
Test data:					
Sieve Size (mm)	Weight of Retained (g)	Retained (%)	Cum. Retained (%)	Passing Percentage (%)	
50.00	0.0	0.00	0.00	100.00	Weight of dry Sample(g) (Before Washed) 431.80
37.50	0.0	0.00	0.00	100.00	
28.00	0.0	0.00	0.00	100.00	Weight of dry Sample(g) (After Washed) 366.00
20.00	0.0	0.00	0.00	100.00	
14.00	16.1	3.73	3.73	96.27	
10.00	3.8	0.88	4.61	95.39	
5.00	11.5	2.66	7.27	92.73	
2.00	57.2	13.25	20.52	79.48	
1.18	57.7	13.36	33.88	66.12	
0.600	58.7	13.59	47.48	52.52	SILT % (<0.06 mm) 15.14
0.425	35.4	8.20	55.67	44.33	SAND % (0.06 - 2 mm) 64.34
0.300	41.6	9.63	65.31	34.69	Gravel (> 2 mm) 20.52
0.150	53.3	12.34	77.65	22.35	
0.063	30.1	6.97	84.62	15.38	
Pan	0.5				
Total	365.9				
					
Comment: "" As stated by the client. This report refers specially to the sample analyzed. This report shall not be reproduced except in full, without the written approval of ELS Laboratory.					
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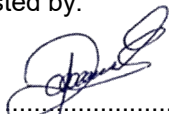
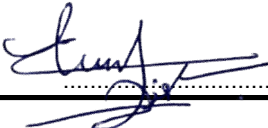


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	NATURAL MOISTURE CONTENT OF SOIL TEST METHOD BS 1377-PART 2		Test Format No:	ELS-INT-S-03
			Revision No.	00
Project data:				
*Project:	GEOTECHNICAL INVESTIGATION FOR THE PROPOSED CENTRAL COLD CHAIN FACILITY WITH CLIMATE-FRIENDLY DESIGNS AT HULHUMALE			
*Client	Design Link Associates (pvt) Ltd			
*Consultant:	-			
*Contractor:	-			
Sample data:				
*Sample Type:	Coral Sand from borehole	Lab ref. No.	OVEI/317/S/01	
*Sample Depth:	3.00 - 3.45	Date of testing:	24.04.2025	
*Sampling Location:	BH-01 (SPT)	Date of report:	28.04.2025	
Test Data:				
Can No:		2E		
Sample Depth	m	3.00 - 3.45		
Weight of Can	g	94.10		
Weight of Can + Wet Soil	g	269.20		
Weight of Can + Dry Soil	g	237.00		
Weight of Dry Soil	g	142.90		
Weight of Water in the Soil	g	32.20		
Moisture Content	(%)	22.53		
<p>Comment: "" As stated by the client. This report refers specially to the sample analyzed. This report shall not be reproduced except in full, without the written approval of ELS Laboratory.</p>				
Tested by:		Checked by	Certified By	
			 	


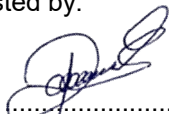
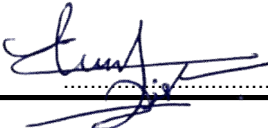


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	NATURAL MOISTURE CONTENT OF SOIL TEST METHOD BS 1377-PART 2		Test Format No:	ELS-INT-S-03
			Revision No.	00
Project data:				
*Project:	GEOTECHNICAL INVESTIGATION FOR THE PROPOSED CENTRAL COLD CHAIN FACILITY WITH CLIMATE-FRIENDLY DESIGNS AT HULHUMALE			
*Client	Design Link Associates (pvt) Ltd			
*Consultant:	-			
*Contractor:	-			
Sample data:				
*Sample Type:	Coral Sand from borehole	Lab ref. No.	OVEI/317/S/01	
*Sample Depth:	3.00 - 3.45	Date of testing:	24.04.2025	
*Sampling Location:	BH-02 (SPT)	Date of report:	28.04.2025	
Test Data:				
Can No:		A2		
Sample Depth	m	3.00 - 3.45		
Weight of Can	g	88.60		
Weight of Can + Wet Soil	g	225.20		
Weight of Can + Dry Soil	g	197.60		
Weight of Dry Soil	g	109.00		
Weight of Water in the Soil	g	27.60		
Moisture Content	(%)	25.32		
<p>Comment: "" As stated by the client. This report refers specially to the sample analyzed. This report shall not be reproduced except in full, without the written approval of ELS Laboratory.</p>				
Tested by:		Checked by	Certified By	
			 	


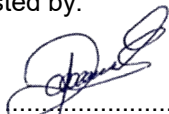
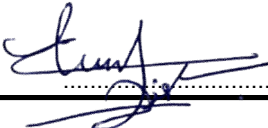
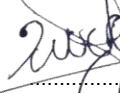

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	NATURAL MOISTURE CONTENT OF SOIL TEST METHOD BS 1377-PART 2		Test Format No:	ELS-INT-S-03
			Revision No.	00
Project data:				
*Project:	GEOTECHNICAL INVESTIGATION FOR THE PROPOSED CENTRAL COLD CHAIN FACILITY WITH CLIMATE-FRIENDLY DESIGNS AT HULHUMALE			
*Client	Design Link Associates (pvt) Ltd			
*Consultant:	-			
*Contractor:	-			
Sample data:				
*Sample Type:	Coral Sand from borehole	Lab ref. No.	OVEI/317/S/01	
*Sample Depth:	3.00 - 3.45	Date of testing:	24.04.2025	
*Sampling Location:	BH-03 SPT)	Date of report:	28.04.2025	
Test Data:				
Can No:		PP-03		
Sample Depth	m	3.00 - 3.45		
Weight of Can	g	101.10		
Weight of Can + Wet Soil	g	284.20		
Weight of Can + Dry Soil	g	245.00		
Weight of Dry Soil	g	143.90		
Weight of Water in the Soil	g	39.20		
Moisture Content	(%)	27.24		
<p>Comment: "" As stated by the client. This report refers specially to the sample analyzed. This report shall not be reproduced except in full, without the written approval of ELS Laboratory.</p>				
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	LIQUID LIMIT AND PLASTIC LIMIT OF SOIL TEST METHOD BS 1377:PART 2		Test Format No:	ELS-INT-S-04	
			Revision No.	00	
Project data:					
*Project:	GEOTECHNICAL INVESTIGATION FOR THE PROPOSED CENTRAL COLD CHAIN FACILITY WITH CLIMATE-FRIENDLY DESIGNS AT HULHUMALE				
*Client:	Design Link Associates (pvt) Ltd				
*Consultant:	-				
*Contractor:	-				
Sample data:					
*Sample Description:	Coral sand from borehole (SPT Sample)	Lab ref. No.	OVEI/317/S/01		
*Sample Location:	BH-01	Date of Testing	24.04.2025		
*Sample Depth:	1.00 - 1.45	Date of Report:	28.04.2025		
Test Data:					
Sample Description:					
Test No.	1	2	3	4	
Number of Blows					
Can No.	NON - PLASTIC (CORAL SAND)				
Weight of Can + Wet Soil					g
Weight of Can + Dry Soil					g
Weight of Can					g
Weight of Water					g
Weight of Dry Soil	g				
Moisture Content	%				
Plastic Limit					
1	2	Average			
X	X				
Liquid Limit Graph					
Moisture Content %					
	Number of Blows				
Liquid Limit	-	Plastic Limit	-	Plasticity Index	-
Comment: "" As stated by the client. This report refers specially to the sample analyzed.					
Tested by:	Checked By:	Certified By:			

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	LIQUID LIMIT AND PLASTIC LIMIT OF SOIL TEST METHOD BS 1377:PART 2		Test Format No:	ELS-INT-S-04							
			Revision No.	00							
Project data:											
*Project:	GEOTECHNICAL INVESTIGATION FOR THE PROPOSED CENTRAL COLD CHAIN FACILITY WITH CLIMATE-FRIENDLY DESIGNS AT HULHUMALE										
*Client:	Design Link Associates (pvt) Ltd										
*Consultant:	-										
*Contractor:	-										
Sample data:											
*Sample Description:	Coral sand from borehole (SPT Sample)	Lab ref. No.	OVEI/317/S/01								
*Sample Location:	BH-02	Date of Testing	24.04.2025								
*Sample Depth:	3.00 - 3.45	Date of Report:	28.04.2025								
Test Data:											
Sample Description:			Plastic Limit								
Test No.		1	2	3	4	1	2	Average			
Number of Blows						X	X				
Can No.		NON - PLASTIC (CORAL SAND)									
Weight of Can + Wet Soil	g										
Weight of Can + Dry Soil	g										
Weight of Can	g										
Weight of Water	g										
Weight of Dry Soil	g										
Moisture Content	%										
Liquid Limit Graph											
Liquid Limit -		Plastic Limit -		Plasticity Index -							
Comment: "*** As stated by the client. This report refers specially to the sample analyzed.											
Tested by:		Checked By:		Certified By:							

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	LIQUID LIMIT AND PLASTIC LIMIT OF SOIL TEST METHOD BS 1377:PART 2		Test Format No:	ELS-INT-S-04							
			Revision No.	00							
Project data:											
*Project:	GEOTECHNICAL INVESTIGATION FOR THE PROPOSED CENTRAL COLD CHAIN FACILITY WITH CLIMATE-FRIENDLY DESIGNS AT HULHUMALE										
*Client:	Design Link Associates (pvt) Ltd										
*Consultant:	-										
*Contractor:	-										
Sample data:											
*Sample Description:	Coral sand from borehole (SPT Sample)	Lab ref. No.	OVEI/317/S/01								
*Sample Location:	BH-03	Date of Testing	24.04.2025								
*Sample Depth:	2.00 - 2.45	Date of Report:	28.04.2025								
Test Data:											
Sample Description:			Plastic Limit								
Test No.		1	2	3	4	1	2	Average			
Number of Blows						X	X				
Can No.		NON - PLASTIC (CORAL SAND)									
Weight of Can + Wet Soil	g										
Weight of Can + Dry Soil	g										
Weight of Can	g										
Weight of Water	g										
Weight of Dry Soil	g										
Moisture Content	%										
Liquid Limit Graph											
Liquid Limit -		Plastic Limit -		Plasticity Index -							
Comment: "" As stated by the client. This report refers specially to the sample analyzed.											
Tested by:		Checked By:		Certified By:							

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DIRECT SHEAR TEST

TEST METHOD- BS 1377 : Part 7 : Sec.4

Test Format No: ELS-INT-S-07
Revision no: 00

Project Data

*Project: GEOTECHNICAL INVESTIGATION FOR THE PROPOSED CENTRAL COLD CHAIN FACILITY WITH CLIMATE-FRIENDLY DESIGNS AT HULHUMALE
*Client: Design Link Associates (pvt) Ltd
*Consultant: -
*Contractor: -

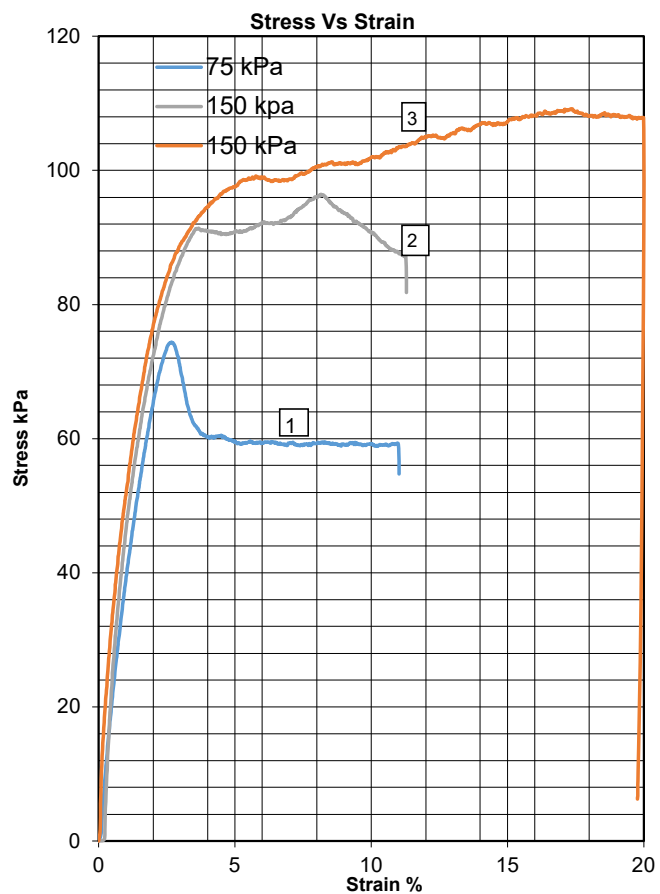
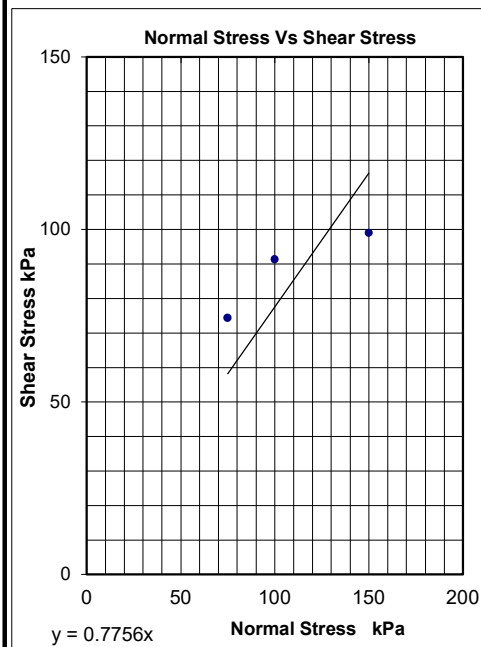
Sample Data

*Depth: 2.00 - 2.45 Lab ref. No.: OVEI/317/S/01
*Location: BH-01 Date of Test: 27.04.2025
*Sample no.: 1 Date of Report: 28.04.2025
*Sample Description: SPT Sample | Coral SAND (Medium dense Sand layer)

Initial specimen data
Length: 6.00 cm Area: 36.0 cm² Height: 2.50 cm Volume: 90.0 cm³

Test Data

Specimen No.	1	2	3
Bulk Density g/cm ³	1.932	1.921	1.973
Moisture Content %	21.4	22.70	22.10
Dry Density g/cm ³	1.592	1.566	1.616
Normal Stress kPa	75	100	150
Strain at failure %	2.7	3.7	5.7
Max. Shear stress kPa	74.4	91.4	99.0



Cohesion c' 0 kPa

Angle of Internal Friction ϕ' 38.0 deg

Note: *Sample description is by Visual Classification

*** As Stated by the Client.

Tested by:

Checked by:

Certified by:

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PARTICLE DENSITY OF SOIL

TEST METHOD : BS 1377- Part 2:1990

Test Format No: ELS-INT-S-08

Revision No. 00

Project data:

*Project:	GEOTECHNICAL INVESTIGATION FOR THE PROPOSED CENTRAL COLD CHAIN FACILITY WITH CLIMATE-FRIENDLY DESIGNS AT HULHUMALE		
*Client:	Design Link Associates (pvt) Ltd		
*Consultant:	-		
*Contractor:	-		

Sample data:

*Sample Type:	Coral Sand From Borehole (passing from 2.00 mm sieve)	Lab Ref. No.	OVEI/317/S/01
*SampleDepth:	3.00 - 3.45	Date of Testing:	24.04.2025
*Sample Location:	BH-01	Date of Report	28.04.2025

Test data:

Identification No	A
Sample Depth (m)	3.00 - 3.45
Mass of Density Bottle(g)	28.93
Mass of Bottle & Dry Soil(g)	77.35
Mass of Bottle,Dry Soil & Water(g)	109.91
Mass of Bottle with Full of Water(g)	79.32
Mass of Soil	48.42
Temperature of Water(⁰ C)	20.00
Density of Water at the Testing temperature(Mg/m ³)	0.9982
Volume of Soil(cm ³)	17.86
Particle Density of Soil (g/cm ³)	2.71

"Comment: """" As stated by the client.
This report refers specially to the sample analyzed."

Tested by:

Checked by

Certified by:



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PARTICLE DENSITY OF SOIL

TEST METHOD : BS 1377- Part 2:1990

Test Format No: ELS-INT-S-08

Revision No. 00

Project data:

*Project:	GEOTECHNICAL INVESTIGATION FOR THE PROPOSED CENTRAL COLD CHAIN FACILITY WITH CLIMATE-FRIENDLY DESIGNS AT HULHUMALE		
*Client:	Design Link Associates (pvt) Ltd		
*Consultant:	-		
*Contractor:	-		

Sample data:

*Sample Type:	Coral Sand From Borehole (passing from 2.00 mm sieve)	Lab Ref. No.	OVEI/317/S/01
*SampleDepth:	3.00 - 3.45	Date of Testing:	24.04.2025
*Sample Location:	BH-02	Date of Report	28.04.2025

Test data:

Identification No	B
Sample Depth (m)	3.00 - 3.45
Mass of Density Bottle(g)	29.00
Mass of Bottle & Dry Soil(g)	78.34
Mass of Bottle,Dry Soil & Water(g)	110.43
Mass of Bottle with Full of Water(g)	79.10
Mass of Soil	49.34
Temperature of Water(⁰ C)	20.00
Density of Water at the Testing temperature(Mg/m ³)	0.9982
Volume of Soil(cm ³)	18.04
Particle Density of Soil (g/cm ³)	2.73

"Comment: """" As stated by the client.
This report refers specially to the sample analyzed."

Tested by:

Checked by

Certified by:



ELS INTERNATIONAL (PVT) LTD)

LEO Office Complex, 2nd Floor, Hulhumale Plot 10693 (M3-60), Haivakaru Magu, Male', Republic of Maldives.

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PARTICLE DENSITY OF SOIL

TEST METHOD : BS 1377- Part 2:1990

Test Format No: ELS-INT-S-08

Revision No. 00

Project data:

*Project:	GEOTECHNICAL INVESTIGATION FOR THE PROPOSED CENTRAL COLD CHAIN FACILITY WITH CLIMATE-FRIENDLY DESIGNS AT HULHUMALE		
*Client:	Design Link Associates (pvt) Ltd		
*Consultant:	-		
*Contractor:	-		

Sample data:

*Sample Type:	Coral Sand From Borehole (passing from 2.00 mm sieve)	Lab Ref. No.	OVEI/317/S/01
*SampleDepth:	3.00 - 3.45	Date of Testing:	24.04.2025
*Sample Location:	BH-03	Date of Report	28.04.2025

Test data:

Identification No	C
Sample Depth (m)	3.00 - 3.45
Mass of Density Bottle(g)	29.14
Mass of Bottle & Dry Soil(g)	75.29
Mass of Bottle,Dry Soil & Water(g)	108.41
Mass of Bottle with Full of Water(g)	79.19
Mass of Soil	46.15
Temperature of Water(⁰ C)	20.00
Density of Water at the Testing temperature(Mg/m ³)	0.9982
Volume of Soil(cm ³)	16.96
Particle Density of Soil (g/cm ³)	2.72

"Comment: """" As stated by the client.
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Tested by:

Checked by

Certified by:



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CHEMICAL ANALYSIS

Test Format No: ELS-INT-CH-1/2/3
Revision No. 0

Project data:

*Project: GEOTECHNICAL INVESTIGATION FOR THE PROPOSED CENTRAL COLD CHAIN FACILITY WITH CLIMATE-FRIENDLY DESIGNS AT HULHUMALE
*Client: Design Link Associates (pvt) Ltd
*Contractor: -

Sample data:

*Sample number: 01 Lab Ref. No.: OVEI/317/S/01
*Sample Description: SPT Sample Date of Testing: 27.04.2025
*Sample Location: BH-03 | 2.00 - 2.45 Date of Report: 30.04.2025

Test Data:

No	Test	Units	Test method	Results
01	PH	-	Electrometry	6.5
03	Water Soluble Chloride Content	ppm or mg/L	BS 1377-Part 03	540
04	Water Soluble Sulphate Content	ppm or mg/L	BS 1377-Part 03	1350

Note:-

PPT or ‰ - Parts Per Thousand TNU - Nephelometric Turbidity Unit PPM- parts per million

* As stated By the client(the information stated by the client may affect the validity of the test results)

* This report refers specifically to the sample analyzed.

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Tested by:

Checked and certified by:



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CHEMICAL ANALYSIS

Test Format No: ELS-INT-CH-1/2/3

Revision No. 0

Project data:

*Project: GEOTECHNICAL INVESTIGATION FOR THE PROPOSED CENTRAL COLD CHAIN FACILITY WITH CLIMATE-FRIENDLY DESIGNS AT HULHUMALE

*Client: Design Link Associates (pvt) Ltd

*Contractor: -

Sample data:

*Sample number: 01 Lab Ref. No.: OVEI/317/S/01

*Sample Description: SPT Sample Date of Testing: 27.04.2025

*Sample Location: BH-01 | 1.00 - 1.45 Date of Report: 30.04.2025

Test Data:

No	Test	Units	Test method	Results
01	PH	-	Electrometry	6.8
03	Water Soluble Chloride Content	ppm or mg/L	BS 1377-Part 03	380
04	Water Soluble Sulphate Content	ppm or mg/L	BS 1377-Part 03	840

Note:-

PPT or ‰ - Parts Per Thousand TNU - Nephelometric Turbidity Unit PPM- parts per million

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Tested by:

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