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NAME OF PROJECT:

CONSTRUCTION OF SINDH PARLIAMENTARIANS RESIDENCES KARACHI

BIDDING DOCUMENTS (VOLUME - II)

SPECIFICATIONS - TECHNICAL PROVISIONS

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CONSULTANT



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SPECIFICATIONS - TECHNICAL PROVISIONS

All items to conform with Sindh Government Schedule of Rates of 2012 Specifications (with their subsequent amendments) except where additional specifications are provided in this section and BOQ, with the following additional stipulations: -

- i) No payment for extra lead and lift will be made.
- ii) The rates being quoted by the Contractor shall include dewatering if required.
- iii) Not with-standing any item of BOQ, **NO LEAD** or **LIFT** for supply of any material/ disposal of any item/ execution of any work would be given to the Contractor. The Contractor is supposed to investigate the source of all materials and ascertain their cost of cartage (including all incidental costs) which would be considered incorporated in the items rates.
- iv) RCC pipes in items to conform to ASTM Specifications C-76.
- v) Sea sand shall be used only for bedding and backfilling under PE Pipe and will not be allowed in any other activity.
- vi) Sea water/ brackish water shall not be used in any construction activity including road construction.
- vii) Any item (i) described in the Bill of Quantities or relevant Specifications but not shown on the Drawings, or (ii) shown on the Drawings but not described in the Bill of Quantities or relevant Specifications, shall be of like effect as it has been shown and mentioned in both. Similarly, if any item which is neither shown on the drawing not mentioned in the Bill of Quantities or Specification but is a pre-condition to carryout any item of the contract, it shall be considered to be included in the contract price, distributed among the rates and prices entered for the related items of works. The decision of the Engineer shall be final and binding on the Contractor, unless before the deadline for submission of Bids, such discrepancies are clarified by the Design Consultant as a result of an inquiry from bidders or on the initiative of the Design Consultant/ Employer. The clarification in either case would be sent to all bidders as an Addendum. However it shall be clearly understood that no extra cost whatsoever shall be paid in case such discrepancies if any, exist in the Bid documents.
- viii) All diameters of pipes and fittings (MS, uPVC, RCC, FC etc.) as mentioned in BOQs shall be minimum clear inner diameters.
- ix) In case of PE Pipe the diameter given in the BOQ shall refer to outer diameter.
- x) Not withstanding anything contained in the Contract Documents, Employer/ Engineer reserves the right to ask for justification/ rate analysis from the contractor of any rate which in the opinion of the Employer/ Engineer is abnormally high or low. Furthermore, the quoted rates, once accepted will be valid only for the quantities mentioned in the BOQ with a variation of $\pm 15\%$. For any further variation, the Employer/ Engineer reserves the rights to reduce any abnormally high rate quoted by the contractor as per Clause 52.2 of the contract.

However, in case of any low rate, no increase in rates will be allowed/ admissible.
- xi) The pament for earthwork for embankment shall be measured from NSL not withstandaing anything written in the Contract. The embankment earthwork between NGC and NSL, if any, shall be deemed to be included in the Contract Price and shall not be measured from payment under earthwork.

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STRUCTURAL WORKS

EXCAVATION, TRENCHING AND BACKFILLING

1. SCOPE

The work covered by this section of the specifications consists of furnishing all plant, labour, equipment, appliances and materials and performing all operations in connection with excavation, trenching and back-filling for sewer and water supply lines and all other structures including all incidental works necessary for excavation to the required depth and dimensions in accordance with the applicable drawings, or as directed by the Engineer. The work shall be carried out in complete conformity with the specifications, set-forth hereunder.

2. SETTING OUT

Lines and levels will be set out by the Contractor who shall be responsible for maintaining all stakes and witness points set-up by the Engineer for the execution of work in strict accordance with them.

3. CLEARING AND GRUBBING

The sites of all excavations shall be cleared of all shrubs, plants, bushes, large roots, rubbish and other objectionable materials. All such materials shall be removed from site of work or otherwise disposed off at no extra cost in a manner satisfactory to the Engineer. All trees and shrubbery that are designated by the Engineer to remain shall be adequately protected and preserved in an approved manner.

4. EXCAVATION

4.1 General

The contractor shall remove the whole of the vegetation, top soil, concrete, flagging, paving, curbing, road metalling and other materials from the site of any excavation and shall keep separately and preserve the same for re-use where applicable. The ground shall be excavated for the permanent and temporary works to the required depths, width and levels so that the dimensions of the permanent work shall not be less than as shown on the Drawings, or as may be directed.

All rubbish, filth and matter of an offensive nature taken out of any excavation shall be disposed off at once and not left on the surface within the site.

4.2 Shoring Excavation

The Contractor shall, to the satisfaction of the Engineer, shore the sides of excavations for structures, trenches and pits to prevent them from slipping or falling. Should any slips fail or settlement nevertheless occur they should be made good by the Contractor at his own expense with selected fill or with mass concrete as may be directed by the Engineer.

In removing shoring from the sides of excavations, care shall be taken to avoid bringing loads on to any concrete until it has hardened sufficiently to carry such loads.

Timber or other material used for shoring the sides of excavations shall be removed as the work proceeds except when ordered to be left, in by the Engineer.

The Contractor shall, not later than four weeks before commencing any excavation, submit to the Engineer for inspection calculations and working drawings for the proposed scheme for strutting and retaining the sides of the excavations and shall not proceed with the appropriate sections of the works until receipt of the Engineer's written consent.

The receipt of such consent shall not relieve the contractor of any of his duties and responsibilities under the Contract.

4.3 Trial / Test Pits

The Contractor may be required to excavate trial pits and trial trenches upto about 10% of the total quantity of excavation specified in the contract at appropriate locations to determine the actual level of the existing water table, and position of existing conduits, water mains, gas mains, cable ducts and sewers etc. This excavation work shall be done carefully with due precaution, so as not to damage any existing services. The Contractor may be precluded from carrying out any permanent work until this information is obtained and may have to adopt his program in accordance with the information so obtained by the Contractor.

Trial test pits will be required to be dug before or during the execution of work at locations directed by the Engineer for determining the condition of soil, checking the location of utility services water levels etc. The size of individual trial pits may be kept 5ft x 5ft up to the required depth. The dimensions may be varied depending upon the site condition and as per instruction of the Engineer. The Contractor shall obtain prior permission from Engineer in writing before start of work on trial pits. No separate payment shall be made for trial pits required to be dug by the Contractor.

The cost incurred by the Contractor on the trial / test pits shall be deemed to be included by the Contractor in his rates for excavation.

4.4 Classification of Soils

Excavation shall include the removal of all materials in all kinds of soils or stratas of every name and nature. The sub- soil in the project area mostly comprises of clay with fine sand and silt and high sub-soil water level. A considerable amount of dewatering and supports for the sides of excavation will be essential including bore holes, well point system and side supports comprising of shuttering, bracing, strutting and sheet piling. However the Contractor shall make his own assessment after detailed study of the area and digging the required trial / test pits as required in this regard. No claim shall be allowed on account of any omission or error in such data trial / test pits.

If rock is encountered it shall be removed carefully and without excessive noise and vibration. Blasting shall not be allowable. The quantities of earthwork for each category of excavation i.e. soil, and rocks are provisional. The Engineer shall do the classification of soil during actual excavation. In case the Contractor meets rock during the excavation, the contractor shall request the Engineer in writing for a joint inspection for classification of soil. The Engineer shall visit the site during excavation and give his opinion in writing about classification of soil for the particular site or alignment.

The excavation payable shall be limited to the dimensions and elevations as indicated on the drawings. Foundations on made up ground shall be taken down to nascent soil as per direction and approval of the Engineer. Excavation shall extend to a sufficient distance away from walls and footings to allow for placing and removal of forms, installation of services and for inspection. No payment shall be made for this extra excavation. The Contractor's rate for excavation shall be deemed to include for such extra excavation.

In the event of any excavation being carried out deeper than specified, the same shall be filled in by the Contractor at his own cost to the required level with lean concrete if beneath footing or with proper compacted local river sand if beneath slab.

4.5 Soil Investigation

This Clause shall apply to soil mechanics as well as foundation engineering to the Site where the works are being constructed, to determine the suitability of the foundation proposed for the works to be constructed on the site.

The Contractor should carry out his own soil investigation to see the soil conditions and its bearing capacity and this should be priced in the Preliminaries Section of the bill of quantities

a) Digital Submittals of Soil Investigation

All reports and drawings shall be submitted in digital form (CD or similar), as follows:

- i). The Contractor shall provide on recordable CD media an identical reproducible copy of the report. This shall be in a PDF format to be directly readable as a single file.
- ii). The Contractor shall provide in digital format all relevant information in an editable Excel spreadsheet form able to be directly convertible in "KEY AGS3". The format spreadsheet will be made available from the Engineer.

The Contractor should make himself aware of the following software to ensure the relevant information and content is provided.

- KEY AGS 97
- HOLEBASE 3
- KEYHOLE 5
- KEYHOLE VETRA

The Contractor shall provide in editable format the following in CD media:

- | | |
|-----------------------|--|
| • *.doc (WinWord) | All report text. |
| • *.jpeg | All borehole records. |
| • *.jpeg | All laboratory test data sheets and results. |
| • *.jpeg | All core photography |
| • *.dwg (AutoCAD V14) | Miscellaneous report drawings |

5. POLYTHENE SHEETING

Polythene sheeting where shown on the drawings shall be Visquenn 1000 super D.P.M. Sheeting manufactured by approved supplier in rolls and laid by rolling over the prepared base at the levels and in the areas shown on the drawings. Where a joint is necessary at the side or end of a sheet this shall be a double welt folded joint made by placing the edges together and folding over twice. The joint shall be prevented from opening prior to concreting by blocks placed at intervals on top of the joint. Particular care shall be taken in forming the joint between horizontal and vertical sheets where the concrete requires to be wrapped so that a continuous damp proof membrane is formed.

The contractor shall protect the sheets from damage during laying and subsequent operations and shall replace all damaged sheets to the satisfaction of the Engineer.

6. PRECAUTIONARY AND REMEDIAL MEASURES

6.1. Protection of Existing Facilities and Structures

The Contractor shall take every necessary precaution not to endanger the safety, occupation or operation of any property, structures, installations or services in the vicinity of his operations and shall observe any restrictions imposed by authority concerned / Engineer to this end. Should any such property, structures, installations or services be endangered or damaged as a result of the Contractor's operations, he shall immediately report any such danger or damage to the Engineer's Representative and any authority concerned and shall forthwith undertake remedial measures to the satisfaction of the Engineer or the appropriate authority.

6.2. Planking and Strutting

The Contractor shall provide, if required, at his own expense to the satisfaction of the Engineer all times support effectively the sides of the pipe trenches and other excavation by suitable timbering, sheet piling, sheeting, bracing, strutting etc. Where required the contractor shall use close timbering in all loose or sandy or unstable stratas both above or below ground level, if found necessary by the Engineer and accord approval. It is intend that all timbering and side supports for sewer trenches shall be removed as the work proceeds. The Contractor shall ensure that the removal of timbering and side supports is done gradually and carefully to avoid any damage to existing or new structures, roads, pavements or any other private or public property. All timbering, sheeting and their supports shall be of adequate strength and dimension and fully braced and strutted so that no collapse, subsidence or any damage to public or private property shall take place. The Contractor shall be solely responsible for the sufficiency of all timbering, sheet piling and their supports to be used and all damages to persons or property resulting from

the improper quality, strength, placing, maintaining or removal of the same shall be payable by him under all circumstances.

In removing timbering, shoring and strutting and all other supports from excavation and trenches etc., special care shall be taken to avoid bringing pressure to bear on any concrete or other work until it has hardened sufficiently to resist such pressure.

6.3. Removal of Water

The Contractor shall build all drains and do ditching, pumping and all other work necessary to keep the excavation clear of sewage, storm water and water from any source during the progress of the work and until the finished work is safe from injury. All water pumped or drained from the work shall be disposed of in a manner satisfactory to the Engineer and necessary precautions against flooding shall be taken. The contractor should submit the Methodology of dewatering for approval. It may also be noted that any approval of the methodology will not relieve the contractor from any of his responsibilities / obligations.

The Contractor shall be required to arrange well point equipment and / or adequate number of tube wells or both and pumping machinery for dewatering and lowering the existing water table for construction purposes in the areas where sub-soil water or any sewage and water from any other sources are encountered. The system shall be capable of working non-stop 24 hours a day for the entire duration of the work without break during excavation, and for laying of sewer, pipes and bedding, construction of manhole, construction of structures, testing of sewers/ pipes and backfilling. The system of dewatering proposed to be adopted shall be submitted by the contractor with sufficient details along with the tender for approval of the Engineer. The Contractor is required to visit the site before submitting his tender and investigate the available means of disposal of pumped water including laying of temporary pipeline for transmission of water during the period of excavation providing bedding, laying & jointing of sewer, pipes and construction of any structure up to ground level. The cost of all such works required for pumping and disposal of water from trenches/ pits shall be considered to be included in the BOQ rates for excavation.

6.4. Maintenance of Excavation

All excavation shall be properly maintained while they are open and land exposed. Sufficient suitable barricades, warning lights, flood lights, signs, and similar items shall be provided by the Contractor. The Contractor shall be responsible for any damage due to his negligence.

6.5. Surplus Materials

All surplus materials shall be disposed of at locations approved by the Engineer. The disposal of surplus material shall not interfere with other works and shall not damage or spoil other material. When it is necessary to haul earth or rock material over street or pavement, the Contractor shall prevent such materials from falling on the street or pavement.

6.6. Cutting Pavement

In cutting or breaking street surfacing, the Contractor shall not use equipment which will damage the adjacent pavement. Existing paved surface shall be cut back beyond the edge of trenches to form neat square cuts. The road ballast and other materials shall be placed on one side and shall be preserved for re-installment when the trench is filled. Wherever necessary or required for the convenience of the public or individual residents, at street crossings and at private driveways, the Contractor shall provide suitable temporary bridges over unfilled excavations. All such bridges shall be maintained in service until backfilling has been completed. The Contractor shall keep the road crossings manned 24 hours per day. During night time, enough red lights shall be provided to warn traffic. If detour is necessary, the Contractor shall make proper detour for the traffic and shall install signs 3 ft x 4 ft in size indicating the detour.

7. FILL, BACKFILLING AND RESTORING OF GROUND TO ORIGINAL CONDITION

- 7.1.** Fill, where required to raise the sub-grade for concrete slabs, shall be clean, unadulterated local river sand and shall be free from wood, stones and other debris. Excavated material shall only be used for fill if approved by the Engineer or his representative.

All fill backfilling or earthwork in embankment shall be compacted by mechanical rammer, or other approved equipment in layers not more than 150 mm thick. Each layer shall be uniformly spread and fully compacted and shall have proper moisture content for the required degree of compaction which shall be done by mechanical tampers as approved by Engineer.

After completion and final approval of the work of sewers and other construction as shown on drawings and prior to backfilling, forms shall be removed carefully and excavation shall be cleaned of stones and debris. Backfill shall be brought to a suitable elevation above ground to provide for anticipated settlement and shrinkage thereof.

Backfill shall not be placed against walls etc., prior to the water proofing treatment if provided and approved by the Engineer. Backfill shall be brought up evenly on each side of walls as far as practicable. Heavy equipment for spreading and compacting backfill shall not be operated closer to the wall than distance equal to the height of the backfill above the top of base slab footing. No back filling shall be done before the new structure has been cured for atleast two weeks.

7.2. Backfilling and Restoring of Ground to Original Condition

The back filling of the trench shall be allowed after the sewer pipe has been laid and jointed over the specified bed, inspected, checked, tested and approved by the Engineer. Backfilling of the trenches shall be carried out by filling to depth up to half pipe level. The filling shall then be thoroughly rammed more filling shall be carried out and rammed again until the consolidated filling reaches pipe top level. Only selected, dry materials free from stones or debris shall be used for backfilling, which shall be spread and rammed evenly across the trench. Thereafter, the trench shall be filled in layers not exceeding 150 mm in depth, each layer being properly rammed before the next layer is placed so that 95-100% compaction is obtained as per AASHTO Standard.

On completion of backfilling, the Contractor shall level all grounds disturbed by him in the course of the work, spread topsoil where necessary as directed by the Engineer.

8. ACCEPTANCE OF EARTHWORK AND FILLING

Acceptance of earthwork and filling shall be determined by testing the degree of compaction and the levels and evenness of surface of the approved materials. Such testing and acceptance shall be performed as the work progresses. Each layer shall be tested and approved prior to progressing with additional layers. The engineer shall have the right to retest any areas at any time and the Contractor shall be responsible for correcting and deficiencies.

9. COMPACTION PROCEDURE

The procedure for compacting the existing sub-grade and any filling material is subject to the approval by the Engineer and shall be generally as outlined below. The adoption of the procedure outlined below and the giving of approval by the Engineer shall not relieve the Contractor of his responsibility in providing compacted soil in accordance with sub-clause a below.

- a) Each layer of profile shall be compacted to give a minimum density of 90% of the Maximum Dry Density throughout the whole thickness of the layer or the top 300 mm of existing sub-grade. The maximum dry density being established by B.S Standard Tests (or AASHO equivalent tests). (B.S test to BS 1377:1975 – Test No. 9 AASHO test to AASHO T 160 – 61).
- b) After carrying out the grading, leveling, scarifying, pulverizing, etc., of the soil layer to be compacted as per specifications, the Contractor shall add the necessary amount of water to permeate the pulverized soil in the quantity required, all in accordance with the instructions of the Engineer.
- c) The soil shall then be thoroughly mixed after adding each lot of water so as to achieve homogenous moisture content in the whole thickness of the layer.
- d) Before compacting, sample from the pulverized soil will be taken and tested, in order to check the natural moisture content and to bring it within +2 and or -4 per cent of the Optimum

Moisture Content. When the material is within this moisture range, it shall be primarily leveled in order to commence earth compaction.

- e) After primary leveling referred to above, compaction shall be commenced by means or approved rollers depending on the type or soil being compacted in order to obtain the required density.
- f) The rolling shall be carried out until the soil reaches the required density. If the surface is super-elevated, rolling shall commence from lower side and continue to the higher side. In order to compensate for the amount of water lost in evaporation in the course of compaction, additional quantities of water shall be added as required.
- g) The surface shall thereafter be leveled longitudinally and transversely by motor graders and finally rolled to achieve uniform compaction free from undulations, soft spots and depressions all in conformity with the allowable tolerances for evenness of surfaces.
- h) Compaction of sloped sections of embankments and ditches shall be carried out as hereinafter specified with regard to pulverization of soil, addition of the necessary water. Shaping and compaction to the required degree of compaction and the required design sections.
- i) The Contractor's attention is drawn to the necessity of providing all machinery, equipment and attachments required for the effective and efficient shaping and compaction of these sloped sections.

10. DEGREE OF COMPACTION

The maximum dry reference density and optimum moisture for earthwork materials shall be determined by the BS or AASHTO tests by using the methods described in Clause A-5 above subject to approval of the Engineer.

The density and thickness of any compacted layer shall be ascertained by obtaining a specimen from the soil after completing compaction in accordance with the B.S or AASHTO Specifications and control curves of dry density compaction and optimum moisture content established for each type of soil material being used. In case this specimen does not conform with the required density and thickness, additional tests may be taken to determine the limits of the failing area, after which the contractor shall scarify, pulverize, water, compact and level the layer again, and if necessary, add new material (or otherwise modify the existing material) at his own expense, all in accordance with specifications, until the required result is obtained. The Contractor shall allow in his daily work program enough time to permit the performance and checking of the above tests, all in accordance with the instructions of the Engineer and under his guidance.

11. BORROW

In case of non-sufficiency of excavated material and un-suitability of earth for backfilling, conforming to the above specifications, such material shall be brought from the approved source, by the Contractor.

12. GRADING

After the completion of all backfilling operations, the Contractor shall grade the work areas to the lines, grades and elevations shown on the drawings or as directed by the Engineer. Finished grading shall not be done until the installation of all utilities of appurtenances has been completed and tested. Prior to final acceptance, all damage due to settlement shall be repaired by an at the expense of the Contractor.

13. TESTING OF SOIL IN PLACE

The Engineer will make tests using the calibrated sand cone method/core cutter method to determine the density of soil in place. If soil in place fails to meet the specified degree of compaction the areas represented by the failing tests shall be removed, replaced and compacted to the specified density in the manner directed by the Engineer and at no additional cost to the Employer.

14. REMOVAL OF EXCESS AND UNDESIRABLE MATERIALS

14.1. Excess and undesirable material from excavation not required for fill or backfill shall be disposed off, removed and / or deposited and leveled on the site where directed by the Engineer. Earth suitable and meant for backfill shall be stored at site in a manner not to interfere with the progress of construction works in progress.

14.2. The Contractor shall keep all excavated soil sprinkled with water during the excavation work so as to prevent any dust nuisance.

14.3. Surplus Excavation Debris etc.

All surplus soil arising out of the work shall be carried away to approved site, within a week, deposited and spread as directed by the Engineer.

The Contractor shall carry out the cutting of existing bituminous road as required for excavation for carrying out the work, to the full depth of hard crest of any existing thickness. The stone metal soling etc. shall be separately stacked along the side of excavation for possible reuse.

15. PROTECTION OF UTILITY SERVICES

15.1 Utility Lines

The Contractor shall take every necessary precaution not to endanger the safety, occupation or operation of any property, structures, installations or services in the vicinity of his operations and shall observe any restrictions imposed by authority concerned / Engineer to this end. Should any such property, structures, installations or services be endangered or damaged as a result of the Contractor's operations, he shall immediately report any such danger or damage to the Engineer's Representative and any authority concerned and shall forthwith undertake remedial measures to the satisfaction of the Engineer or the appropriate authority.

When any existing utility lines are encountered within the area of operations, the contractor shall take all necessary measures so that these are neither disturbed nor damaged. The Contractor shall be fully and solely responsible for any damage occurring due to non-providing of adequate measures for the protection of such services. The Contractor shall be required to obtain all necessary permissions from different departments / agencies in writing prior to start of work and maintain the affective liaison for trouble free progress of work(s). The contractor shall pay all fees, charges officially levied by such department / agencies while issuing required permission. The Contractor shall furnish originals of payment receipts alongwith his written request for allowing payments by the Engineer accordingly. In case of restoration to unavoidable damage to any utility service, line or by passing such line the procedure as detailed shall be followed in accordance with rules, regulation, specification or practice as preferred by the concerned department / agency.

15.2 Damage to Surface

If carriage ways, verges or footways in roads, whether paved or unpaved, or gardens, plantations or other surfaces are damaged outside the limits of the excavations due to lack of proper traffic control or moving plant and equipment or other operations of the contractor then such surfaces shall be reinstated by the contractor at his own expenses. The surfaces shall be restored to their original condition using such materials as may be required whether obtained from the excavated materials or not.

15.3 Maintenance of Traffic

The Contractor shall keep the road crossings manned 24 hours per day. During night time, enough red lights shall be provided to warn traffic. If detour is necessary, the Contractor shall make proper detour for the traffic and shall install signs 3 ft x 4 ft in size indicating the detour.

When the excavation is in roads, care shall be taken to cause the least inconvenience to traffic. When directed or necessary for the maintenance of traffic, the contractor shall remove from the site all materials as excavated from the trenches and return the same as necessary for refilling after the structures have been completed or the pipes tested and approved.

15.4 Control of Traffic on Roads

The Contractor shall ensure that the flow of traffic over the existing roads and access to properties is maintained at all times during the contract. The flow of traffic is to take place at all time over a reasonable surface, which is to be segregated as far as possible from areas where work is in progress. The contractor shall provide flagmen and signaling equipment as may be necessary to control the traffic to the satisfaction of the Engineer and the appropriate controlling Authority. In the planning and execution of any temporary or permanent works, which may effect the traffic flow and / or access to properties, the contractor shall co-operate closely with the Engineer and the appropriate controlling Authority.

16. MEASUREMENT AND PAYMENT

16.1 Excavation and Backfilling

Measurement and payment for excavation and filling shall be made in accordance with the following provision:

a) Method of Measurement

The measurement shall be made of the earth acceptably excavated for trenches and structures within the lines and grades shown on the drawing or as directed by the Engineer.

b) Basis of Payment

- i). Payment for earth excavations for trenches and structures will be made at unit price stated in Bid Schedule of this contract or in applicable Variation Orders.
- ii). For the purpose of measurement, the depth of filling shall be taken as consolidated depth.

PLAIN & REINFORCED CONCRETE

1. SCOPE OF WORK

The work to be done under this section of the specifications shall consist of furnishing all plant, labour, equipment, appliances and materials and in performing all operations in connection with providing and placing plain and reinforced cement concrete, in position as shown on the drawings including furnishing formwork, batching, mixing, finishing and curing as per drawings or as directed by the Engineer.

2. CLASSES OF CONCRETE

The classes of concrete recognized in these specifications shall be designated: A, B, C, D1, D2, D3, Y and Lean concrete. The class of concrete to be used shall be as called for on the Drawings or as directed by the Engineer or specified in the special provisions. The following requirements shall govern unless otherwise shown on the Drawings.

Class A1 concrete shall be used everywhere, for non-reinforced and reinforced concrete structures, except as-noted below or directed by the Engineer. Concrete placed underwater shall be Class A2 with a minimum cement content of three hundred fifty (350) kg per cubic meter of concrete with a slump between ten (10) and fifteen (15) cm. Concrete placed for piles shall be Class A3 with a minimum content of four hundred (400) kg per cubic meter.

Class B Concretes shall be used only where specified.

Class C concretes shall be used for cribbing, or as otherwise directed by the Engineer or specified in the Special Provision or on the Drawing.

Class D1, D2 or D3, concrete shall be used for pre-stressed and post-tensioned elements, as indicated on drawings.

Class Y concrete shall be used as a filler in steel grid bridge floors, in thin reinforced sections or as otherwise specified in the Special Provisions.

Lean concrete shall be used in thin layers underneath footings and when called for on the Drawings or directed by the Engineer.

The concrete of the various classes shall satisfy the requirements shown in Table.

**Table
Portland Cement Concrete Requirement**

Class of Concrete	Min. cement Kg/ Cubic Meter	Max. Size of Coarse Aggregate (mm)	28 days compressive strength (Min) (Cylinder) (Kg/ Sq.cm.)	Consistency (Range in Slump) Vibrated (mm)	Maximum permissible water-Cement Ratio
A1	300	20	210	25-75	0.58
A2	350	25	245	100-150	0.58
A3	400	38	280	100-150	0.58
B	250	51	170	25-75	0.65
C	275	38	210	25-75	0.58
D1	450	25	350	50-100	0.40
D2	500	25	425	50-100	0.40
D3	550	25	500	50-100	0.40
Y	400	13	210	25-75	0.58
Lean Concrete	175	51	100	-	-

2.1. Types of Concrete Works

2.1.1 Underground Concrete

Concrete poured below Natural Surface Level with or without shuttering and shoring.

2.1.2 On-ground Concrete

Concrete poured by existing formwork with necessary bracings on ground.

2.1.3 Elevated Concrete

Concrete poured by existing props, bracing and towers to support the formwork at higher levels.

3. EFFECT OF MATERIALS STRENGTH

The cement and aggregate used have significant influence on strength properties. The use of unsound aggregates will produce large variations in the strength of concrete. In general, however, a good aggregate will develop the full strength of the cementing matrix and therefore should cause little variation in the product. Strength increases slightly with larger size coarse aggregates.

4. MATERIALS

4.1 Cement

- i). The cement shall be fresh and of approved origin and manufacture, it shall be one of the following as may be specified by the Engineer.
 - a). Ordinary or Rapid Hardening Portland Cement shall comply with the requirements of PS 232 or BS 12.
 - b). Sulphate-Resisting Portland Cement complying with the requirements of PS 612 or BS 4027.
- ii). Unless otherwise specified, ordinary Portland Cement shall conform the requirements of the standard specifications for Portland Cement, AASHTO Designation M55, ASTM Designation C150.
- iii). Mill Certificates shall accompany delivery of the material to the work.
- iv). There shall be sufficient cement on site to ensure that each section of work is completed without interruption. If the cement is supplied by the Employer, the contractors should inform the Employer of his requirements much before its use in construction.
- v). Cement reclaimed from cleaning of bags or from leaky containers shall not be used.
- vi). The Contractor shall provide and erect (at his cost) in a suitable place dry, well ventilated, weather-proof and waterproof shed of sufficient capacity to store the cement.
- vii). The cement shall be used as soon as possible after delivery and cement which has become stale or unsuitable through absorption of moisture from the atmosphere or otherwise shall be rejected and removed immediately from the site at the Contractor's expense. Any cement in containers damaged so as to allow the contents to spill or access of the atmosphere to the cement prior to opening at the time of concrete mixing shall be rejected and removed immediately from the site at the Contractor's expenses.
- viii). Cement stored through a monsoon or for more than six months should not be used in reinforced concrete.
- ix). Different brand or different types of cement from the same mill, or the same brand or type from differing mills shall not be mixed or used alternately in the same item of construction unless authorized by the Engineer, after preparing new mix designation.

4.2 Water

The water for curing, for washing aggregates and for mixing shall be fresh, clean, clear, potable and free from impurities & deleterious matter. Water containing less than 2000 parts per million (ppm) of total dissolved solids with following limits on contaminants, recommended to be used for concrete.

Contaminants	Conventional Reinforced Concrete	Pre-stressed Concrete	Non-reinforced Concrete
OIL	None	None	None
CHLORIDES, ppm	1,000	650	2,000
SULPHATES, ppm	1,000	800	1,500

In no case shall the water contain an amount of impurities that will cause arrange in the setting time of Portland cement of more than twenty five (25) percent nor a reduction in the compressive strength of mortar at fourteen (14) days of more than five (5) percent when compared to the result obtained with distilled water.

In addition to the above requirements, water for curing concrete shall not be contain any impurities in a sufficient amount to cause discoloration of the concrete or produce etching of the surface.

When required by the Engineer, the quality of the mixing water shall be processed by the standard method of test for quality of water to be used in concrete. AASHTO Methods of Sampling and Testing, Designation T26 and BS 12.

5. AGGREGATES

- a) The quality and sources of all aggregates for concrete shall be approved by the Engineer before the materials are delivered to the site. Aggregates shall be obtained from a source known to produce aggregates satisfactory for concrete and shall be chemically inert, strong, hard, durable of limited porosity and free from adhering coatings, clay lumps, coal and coal residues, and organic or other impurities that may cause corrosion of the reinforcement or may impair the strength or durability of the concrete.

The aggregates, if directed by the Engineer shall be tested in accordance with the requirements of BS 812.

- b) Wherever feasible the nominal maximum size of aggregate for cast-in-place reinforced concrete slabs and other thin members shall also be 20mm ($\frac{3}{4}$ "). If there are difficulties in placing such a concrete the maximum size may be restricted to 12mm ($\frac{1}{2}$ ") provided the requirements for strength are satisfied.
- c) The nominal maximum size of the aggregate for precise concrete shall not be large than one-fifth of the narrowest dimension between sides of forms, one-third of the depth of slabs, nor three-fourths of the minimum clear distance between reinforcing bars or between bars and forms, whichever is least. In precast columns the nominal maximum size of the aggregate shall be limited as above but shall not be larger than two-thirds of the minimum clear distance between bars.

d) Fine Aggregates

Fine aggregate shall be hard coarse sand, crushed stone or gravel screening and shall conform to the requirements of PS 243 and / or BS 882. Only fine aggregate of grading zones 1 to 3 (BS 882) mainly passing a 3/16 inch BS shall be used, aggregate of zones 4 may be used for special mixes.

Fine aggregates shall conform to BS 882 Grading Zone 1 and 2 and shall be graded as follows:

B.S. Sieve	Percentage (by weight) passing	
	Grading Zone 1	Grading Zone 2
3/8"	100	100
3/16"	90 - 100	90 - 100

B.S. Sieve	Grading Zone 1	Grading Zone 2
No. 7	60 - 95	75 - 100
No. 14	30 - 70	55 - 99
No. 25	15 - 34	35 - 59
No. 52	5 - 20	8 - 30
No. 100	0 - 10	0 - 10

e) Coarse Aggregate

Coarse Aggregates shall be crushed stones, comprising of angular or rounded in shape and shall have granular or crystalline or smooth (but not glassy) non powdery surface free from friable, flaky and laminated pieces, mica and shale and all such matters as may be injurious to the concrete. All coarse aggregate shall conform to BS.

f) Storage

All aggregates shall be stored on properly constructed paving and bins or as directed by the Engineer. There shall be a physical partition between the stockpiles of coarse and fine aggregates. If required aggregates shall be washed and screened to the satisfaction of the Engineer.

g) Sieve Analysis

Sieve analysis of all the aggregates to be used in the works shall be carried out as and when required by the Engineer. All aggregates shall be subject to the approval of the Engineer.

f) Rejected Aggregates

Any aggregates not found to be of the specified standard shall be rejected by the Engineer and all such rejected material shall have to be removed from site without delay.

Concrete structures constructed with rejected aggregates shall be dismantled and rebuilt at the Contractor's expense.

6. COMPOSITION OF CONCRETE

a) Cement and Aggregates

The fine aggregate and the coarse aggregates shall be measured separately by weight. The proportions weight of cement to fine aggregate and coarse aggregate shall be determined by mix design approved by the Engineer. The Contractor shall propose mix designs duly supported by cube tests for each grade of concrete for the approval of the Engineer.

b) Water Cement ratio

The quality of water used shall be just sufficient to produce a dense concrete of adequate strength and workability for its purpose. For all external if work and foundations the water / cement ratio shall not exceed 0.55.

c) Workability

The workability shall be controlled by direct measurement of the water content, allowance being made for any water in the fine and coarse aggregates. The concrete shall be just sufficiently workable to be placed and compacted, without difficulty, by the means available.

The workability shall be determined by either the slump or compaction factor tests as directed by the Engineer and these shall be performed in accordance with the methods given in PS 422 and PS 717. The slump or compaction factor for each grade of concrete shall be determined during the Preliminary Test mixes and the value obtained shall not be modified without the written consent of the Engineer. Unless otherwise permitted or specified, the concrete shall be pro- portioned and produced to have a slump of 75 mm or less if consolidation is to be done by vibration, and 125mm or less if consolidation is to be by methods other than vibration. A tolerance of upto 25mm above the indicated maximum shall be allowed for individual batches provided the average for all batches or the most recent 10 batches tested, whichever is fewer, does not exceed the maximum limit, Concrete of lower than usual slump may be used provided it is properly placed and consolidated.

7. PLASTICIZER / ADMIXTURE

Admixtures shall only be allowed to be used with written permission of the Engineer. If air-entraining agents, water reducing agents, set retarders or strength accelerators are permitted to be used, in exact dosage recommended by the manufacturer.

The Contractor shall submit concrete mix design for approval, prior to the commencement of work. No work shall be carried out without getting written approval of concrete Design Mix from the Engineer.

8. FORMWORK

a). General

- The form work shall be inclusive of all labour, material, workmanship and alike. All form work and the Contractor thereto shall design supports and relevant drawings shall be submitted to the Engineer and his Representative for approval before the work is put in hand. Such an approval shall not relieve the contractor from all the obligations of the contract or give rise to any claim.
- Earth cuts shall not be used as forms for vertical surface of reinforced concrete work unless required or permitted.
- Mud centering shall not be permitted.
- Formwork shall be of wrought timber, steel, plywood, proprietary building boards which gives the required finish to the surface of concrete. Wooden formwork shall be free from loose knots and shall be well seasoned.
- The formwork shall conform to the shape, line and dimension as shown on the plans and be so constructed as to remain sufficiently rigid during the placing and compacting of the concrete and shall be sufficiently tight to prevent loss of liquid from the concrete.

The design and engineering of the formwork as well as its construction shall be the responsibility of the contractor. Where necessary to maintain the specified tolerances the formwork shall be cambered to compensate for anticipated deflections in the formwork due to the weight and pressure of the fresh concrete and due to construction loads. Design of formwork shall, in general, conform to ACI 347-68.

In normal circumstances (General where temperatures are above 20°C (68°F)) and where ordinary cement is used forms may be struck after expiry of the following periods:

Concrete work	Period
Walls, columns and vertical sides of beams	48 hours or as may be decided by the Engineer.
Slabs (shores or props left under)	6 days
Beams soffits (shores or props left under)	12 days
Removal of shores or props to slabs:	
i). Spanning upto 14 ft	10 days
ii). Spanning above 14 ft.	16 days
Removal of shores or props to beams:	
i). Spanning upto 20 ft	18 days
ii). Spanning above 20 ft.	25 days

For rapid hardening cement 3/7 of the above period will be sufficient in all cases except vertical sides of slabs beams and columns which should be retained for minimum 24 hours.

b). Making Forms

Concrete forms shall be constructed and maintained so as to prevent warping and the opening of joints due to the shrinkage of the lumber and shall be true to the dimensions, lines and grades of the structure and with the sufficient strength, rigidity, shape and surface

smoothness as to leave the finished works true to the dimensions shown on drawings or required by the Engineer and with the surface finish as specified.

Dimensional Tolerances

Dimensions	Permissible Deviation (mm)
Position on plan of any point measured from the nearest Grid line.	+5
Vertically Plumbness in height 1 in 400. Maximum permitted.	+10
Cross section and linear dimensions of beams, slabs, columns and walls Up to and including 1m.	+7
Over 1m up to and including 15m.	+15
Bow and camber other than designed camber of any Point of the surface from a straight line joining the Extremities of that surface up to and including 3m apart.	+5
Level from designed level with reference to the nearest Datum of the upper or lower surface as may be specified of any slab or other element or component.	+10

Forms for exposed surfaces shall preferably be lined with, plywood, or other approved material, or may with the Engineer's permission, be made of dressed lumber of uniform thickness. Forms shall be filled at all sharp corners (Minimum two (2) cms triangular, fillets) and shall be given a level or draft in the case of all projections, such as girders and copings, to ensure easy removal.

Form fasteners consisting of form bolts, clamps or other devices shall be used as necessary to prevent spreading of the forms during concrete placement. Bolt and tie positions shall be arranged to conform to the symmetry of formwork panels. The use of ties consisting of twisted wire loops to hold forms in position will not be permitted. Metal ties or anchorage within the forms shall be so constructed as to permit their removal to the minimum depth of cover for the class of concrete and exposure condition.

Fitting for metal ties shall be of such design that, upon their removal, the cavities that are left will be of the smallest possible size. The cavities shall be filled with cement mortar and the surface left sound, smooth, even, and uniform in colour. Anchor devices may be cast into the concrete for later use in supporting forms or for lifting precast members. The use of driven types of anchorage's for fastening forms or form supports to concrete will not be permitted.

Void formers shall be secured in position at regular intervals to prevent displacement and distortion during concreting. The void formers shall be supported on precast concrete blocks or rigid welded steel cradles to the approval of the Engineer. The ties securing the void formers shall be attached to the formwork and cross bearers of the falsework. The void formers shall not be tied to or be supported on the reinforcement.

The inside surfaces of forms shall be cleaned of all dirt, mortar and foreign material. Forms which will later be removed shall be thoroughly coated with form oil prior to use. The form oil shall be a commercial quality form oil or other approved coating which will permit the ready release of the forms and will not discolour the concrete. Care shall be taken to ensure that the lubricant does not come into contact with the reinforcement. All exposed surfaces of similar portions of the concrete structure shall be formed with the same forming material or with materials which produce similar concrete surface textures, colour and appearance.

Concrete shall not be deposited in the forms until all work in connection with constructing the forms has been completed, all materials required to be embedded in the concrete have been placed for the unit to be poured, and the Engineer has inspected and approved said forms and materials.

The rate of depositing concrete in forms shall be such as to prevent deflections of the forms or form panels in excess of the deflections permitted by these specifications. Maximum deflection allowed due to prop settlement is 5 mm and due to bending of shutters is 3 mm, when measured with 3 meter straight edge.

Forms for all concrete surfaces, which will not be completely enclosed or hidden below the permanent ground surface, shall conform to the requirements herein for forms for exposed surfaces. Interior surfaces of underground drainage structures shall be considered to be completely enclosed surfaces.

Formwork for concrete placed under water shall be watertight. When lumber is used, this shall be planed and tongued and grooved.

Forms for exposed concrete surfaces shall be designed and constructed so that the formed surface of the concrete does not undulate excessively in any direction between studs, joists, form stiffeners, form fasteners, or wale's undulations exceeding two (2) mm of the center to center distance between studs, joints, form stiffeners, form fasteners, or wales will be considered to be excessive. Should any form or forming system, even though previously approved for use, produce a concrete surface with excessive undulations, its use shall be discontinued until modifications, satisfactory to the Engineer have been made. Portions of concrete structures with surface undulations in excess of the limits herein may be rejected by the Engineer, and he may ask the contractor for the rectification measures.

Forms shall be set and maintained true to the line designated until the concrete is sufficiently hardened. Forms shall remain in place for periods, which shall be determined, as herein specified. When forms appear to be unsatisfactory in any way, either before or during the placing of concrete, the Engineer will order the work stopped until the defects have been corrected.

The shape, strength, rigidity, water-tightness, and surface smoothness of reused forms shall be maintained at all times. Any warped or bulged lumber must be resized before being reused. Forms that are unsatisfactory in any respect shall not be reused.

For narrow walls and columns, where the bottom of the form is inaccessible, the lower form boards shall be adjustable so that they may be removed for cleaning out extraneous material immediately before placing the concrete.

c). Rigid with Allowance for Camber and Bulges

It shall be fabricated and erected in position, perfect in alignment, levels and true to plumb and shape and securely braced so as to enable it to with stand all weights, live and vibrating, to be endured during placing of concrete and its subsequent hardening till the form work is struck. It shall be sufficiently rigid as not to loose its form or bulge, or deflect and to give the finished concrete the required lines, plumb, size and shape.

d). Materials and Labour

The Contractor shall supply all materials and labour, necessary for a good and speedily erection of form work such as shuttering, planks, struts, bolts, stays, gangways, boards, fillets etc. and shall do all that is essential in executing the job in a workman like manner to the satisfaction of the Engineer.

e). Form work not to interfere or injure work

The form work shall be so designed and arranged as not to unduly interfere with concrete, during its placing and easy to be removed without injuring the finished concrete.

Wedges, clamps, bolts and the rods shall be used, when permitted and where practicable, in making the form work rigid and in holding it to true position.

f). Joints in Formwork

All joints in the form work shall be sufficiently closed to prevent undue leakage of mortar from concrete or show any appearance of leaking mortar on concrete surface.

g). Treatment and Inspection of Forms

All rubbish particularly chipping, shavings and saw dust etc. shall be removed from the interior of the forms, immediately before placing concrete. Forms shall be coated with

approved mould oil before reinforcement is placed. Surplus oil on forms and any oil on reinforcing steel shall be removed.

h). Removal of Form Work

In the determination of the time for the removal of formwork consideration shall be given to the location and character of the structure, the weather and other conditions influencing the setting of the concrete and the materials used in the mix.

The following periods, exclusive of the days when the temperature is below two (2) degree C, for removal of forms and supports shall be used as a minimum subject to the approval of the Engineer.

Arch Center	14 days
Centering Under Beams	14 days
Supports under Flat Slabs	14 days
Floor Slabs	14 days
Vertical Wall Surfaces	24 Hours
Columns	24 Hours
Side of Beams	36 Hours
Top Slabs R.C. Box Culverts	14 days

However, when the temperature remains Five (5)°C or below the period of false work removal shall be extended and shall be advised by the Engineer, whereas the period for which the temperature is below Two (2)°C that period shall be disregarded in calculating the minimum time which elapses before form work is removed.

Side forms for precast members may be removed the next day not before (i.e. 24 hours) after placing concrete therein.

If high early strength cement is used, these periods may be reduced as directed by the Engineer.

All forms shall be removed except where no permanent access is available to the cells. The forms supporting the deck of box girders and the forms in hollow abutments or piers may remain in place. Prior to completion of fixing the deck forms, the inside of box girders shall be cleared of all loose material and swept clean.

Methods of form removal likely to cause overstressing of the concrete shall not be used. In general, the forms shall be removed from the bottom upwards. Forms and their supports shall not be removed without approval. Supports shall be removed in such a manner as to permit the concrete to uniformly and gradually take the stresses due to its own weight.

In general, arch centering or falsework shall be struck and the arch made self-supporting before the railing or coping is placed. This precaution is essential in order to avoid jamming of the expansion joints and variations in alignment. For tiled spandrel arches, such portions of the spandrel walls shall be left for construction subsequent to the striking of centers, as may be necessary to avoid jamming of the expansion joints.

Centers shall be gradually and uniformly lowered in such a manner as to avoid injurious stresses in any part of the structure. In arch structures of two or more spans, the sequence of striking centers shall be approved by the Engineer.

i). Injury or damage

The Contractor shall be responsible for any injury to the work and any consequential damages caused by or arising from the removal and striking of forms, centering and supports, and any advice, permission or approval given by the Engineer or his Authorised Representative, related to the removal and striking of forms, centering and supports shall not relieve the Contractor from the responsibilities herein defined.

j). Treatment after Removal of Forms

Any minor surface honey combing or other irregularities are to be properly made good immediately upon the removal of the form work and the surface made good to the satisfaction of the Engineer and his Representative. Any small voids shall be neatly stopped with cement mortar consisting of one part of cement to two parts of sand and the whole surface rubbed over with carborundum stone and cement wash and bring the whole to a smooth and pleasing finish and uniform colour.

- k).** Form work shall not be measured or paid for separately and shall be deemed to be included in the unit price of concrete whether cast-in-situ or precast and subsequently fixed in position.

9. BATCHING OF CONCRETE

The Contractor shall provide such means and equipment as are required to determine accurately control the amount of each separate ingredient entering the concrete. Such means, the equipment and its operation shall at all times be subject to approval by the Engineer. The amount of cement, water, sand and each size of coarse aggregate entering each batch of concrete shall be determined by weighing or by volumetric measurement if permitted by the Engineer.

10. MIXING CONCRETE

10.1 Mixings General

The concrete shall be mixed only in the quantity required for immediate use. Concrete that has developed an initial set shall be rejected.

Concrete shall be thoroughly mixed in a mixer of an approved size and type that will ensure a uniform distribution of the materials throughout the mass.

All concrete shall be mixed in mechanically operated mixers. Mixing plant and equipment for transporting and placing concrete should be arranged with an ample auxiliary installation to provide a minimum supply of concrete in case of breakdown of machinery or in case the normal supply of concrete should be disrupted. The auxiliary supply of concrete shall be sufficient to complete the casting of a section up to a construction joint

Equipment having components made of aluminum or magnesium alloys, which would have contacted with plastic concrete during mixing, transporting or pumping of Portland cement concrete, shall not be used.

Concrete mixers shall be equipped with adequate water storage and a device for accurately measuring and automatically controlling the quantity of water used.

Materials shall be measured by weighing except as otherwise specified or where other methods are specifically authorized by the Engineer. The apparatus provided for weighing the aggregates and cement shall ensure accurate measurement of each ingredient.

The accuracy of all weighing devices except that for water shall be such that successive quantities can be measured to within one (1) percent of the desired value. Cement in standard packages (bags) approved by the Engineer need not be weighed. The water measuring device shall be accurate to plus or minus half percent $\pm 0.50\%$. All measuring devices shall be subject to the approval of the Engineer. Scales and measuring devices shall be tested at the expense of the Contractor as frequently as the Engineer may deem necessary to ensure their accuracy.

Weighing equipment shall be isolated so that vibration or movement of other operating equipment do not effect the accuracy of reading. When the entire plant is running, the scale reading at cut-off shall not vary from the weight designated by the Engineer more than one (1) percent for cement, one and half (1½) percent for any size of aggregate or one (1) percent for the total aggregates in any batch. Where volumetric measurements are authorized by the Engineer the weight proportion shall be converted to equivalent volumetric proportions. In such cases, suitable allowances shall be made for variations in the moisture condition of the aggregates, including the bulking effect in the fine aggregates. Boxes or similar containers of the exact volume required shall be filled and struck off. Measurement by wheel barrow volumes will not be permitted.

10.2 Mixing at Site

Concrete mixers may be of the revolving drum or the revolving blade type and the mixing drum or blades shall be operated uniformly at the mixing speed recommended by the manufacturer. The pick-up and throw-over blades of mixer shall be restored or replaced when any part or sections is worn two and half (2.5) cms. or below than the original height of the manufacturer's design. Mixers and agitators, which have an accumulation of hard concrete or mortar, shall not be used.

When bulk cement is used and volume of the batch is one cubic meter or more, the scale and weigh hopper for Portland cement shall be separate and distinct from the aggregate hopper or hoppers. The discharge mechanism of bulk cement weigh hopper shall be interlocked against opening before the full amount of cement is in the hopper. The discharging mechanism shall also be interlocked against opening when the amount of cement in the hopper is underweight by more than one percent or overweight by more than three (3) percent of the amount specified

When the aggregates contain more water than the quantity necessary to produce a saturated surface-dry condition, representative samples shall be taken and the moisture content determined for each kind of aggregate.

The temperature of mixed concrete immediately before placing, shall be not more than thirty two (32) degree C. Aggregates and water shall be cooled as necessary to produce concrete within this temperatures limit. If ice is used to cool the concrete, discharge of the mixer will not be permitted until all ice is melted.

The batch shall be so charged into the mixer that some water will enter in advance of cement and aggregates. All water shall be in the drum by the end of the first quarter of the specified mixing time.

Cement shall be batched and charged into the mixer by means that will not result in loss due to the effect of wind, or in accumulation of cement on surfaces of conveyors or hoppers, or in other conditions which reduce or vary the required quantity of cement in the concrete mixture.

The entire contents of a batch mixer shall be removed from the drum before materials for a succeeding batch are placed therein. The materials composing a batch except water shall be deposited simultaneously into the mixer.

All concrete shall be mixed for a period of not less than one and half (1½) minutes after all materials, including water, are in the mixer. During the period of mixing, the mixer shall operate at the speed for which it has been designed.

Mixers shall be operated with an automatic timing device that can be locked by the Engineer. The time device and discharge mechanism shall be so interlocked that during normal operation no part of the batch will be discharged until the specified mixing time has elapsed. In case of failure of the timing device, the Contractor will be permitted to operate while it is being repaired, provided he furnishes an approved timepiece equipped with minute and second hands. If the timing device is not repaired within twenty four (24) hours, further use of the mixer will be prohibited until repairs are made.

The first batch of concrete material placed in the mixer shall contain cement, sand and water in excess to the requirement of mix, to ensure that the drum does not extract mortar from the mix changing its design characteristics. When mixing is to stop for a period of one hour or more, the mixer shall be thoroughly cleaned.

10.3 Plant Mixing

At central mixing plant, batches shall be discharged from the weighing hopper into the mixer either directly by gravity or by an elevating container large enough to contain the batch. The plant shall be arranged to ensure that there is no loss of cement during transfer from weighing hopper to the mixer drum. The mixing time shall neither be less than fifty (50) second, nor more than ninety (90) seconds.

The plasticizer, accelerator or retarder or water reducing admixture, if required, shall be fed separately at the rate recommended by the manufacturer, as established by laboratory trials.

10.4 Transit Mixing

Truck mixers, unless otherwise authorized by the Engineer shall be of the revolving drum type, watertight and so constructed that the concrete can be mixed to ensure a uniform distribution of materials throughout the mass. All solid materials for the concrete shall be accurately measured and charged into the drum at the proportioning plant. The truck mixer shall be equipped with a device by which the quantity of water added can be readily verified. The mixing water may be added directly to the batch, in case the concrete batch is poured within twenty five(25) minutes of adding water.

The maximum size of batch in truck mixers shall not exceed the maximum rated capacity of the mixer as stated by the manufacturer, and stamped in metal on the mixer. Truck mixing shall be continued for not less than fifty (50) revolutions after all ingredients including water, are in the drum. The mixing speed shall not be less than six (6) rpm, nor more than ten (10) rpm.

Mixing shall begin within thirty (30) minutes after the cement has been added either to the water or aggregate but when cement is charged in to a mixer drum containing water or surface-wet aggregate and when the temperature is above thirty two (32) degree C, this limit shall be reduced to fifteen (15) minutes. The limitation in time between the introduction of the cement to the aggregate and the beginning of the mixing may be waived when, in the judgment of the Engineer the aggregate is sufficiently free from moisture, so that there will be no harmful effects on the cement.

10.5 Partial Mixing at the Central Plan

When a truck mixer, or an agitator provided with adequate mixing blades, is used for transportation the mixing time at the stationary plant mixer may be reduced to thirty (30) seconds and the mixing completed in a truck mixer/agitator. The mixing time in the truck mixer or agitator equipped with adequate mixing blades shall be as specified for truck mixing.

10.6 Stiff Concrete Mix

For mixing concrete of zero slump to be laid by pavers, gravity mixer shall not be used. Only force mixer of moving blades shall be allowed to ensure homogenous mix.

10.7 Hand Mixing

Hand mixing of materials shall not be allowed in any case.

11. CONSOLIDATION

a). All concrete shall be consolidated by vibration, spading, roding or forking so that the concrete is thoroughly worked around the reinforcement, around embedded items and into corners of forms, eliminating all air or stone packets which may cause honey-combing, pitting or planes of weakness. Internal vibrators shall have a minimum frequency of 8000 vibrations per min. and sufficient amplitude to consolidate the concrete effectively. They shall be operated by competent workmen, use of vibrators to transport concrete with forms shall not be allowed. Vibrators shall be inserted and withdrawn at points approximately 450mm (18") apart. At each insertion, the duration shall be sufficient to consolidate the concrete but not sufficient to cause segregation, generally from 5 to 15 seconds. A spare vibrator shall be kept on the job site during all concrete placing operations.

b). Over-vibration or vibration of very wet mixes is harmful and should be avoided.

12. HAULING & DELIVERY OF MIXED CONCRETE

12.1 Hauling

Mixed concrete may be transported to the delivery point in truck agitators or truck mixers operating at the speed designated by the manufacturer, provided the consistency and workability of the mixed concrete upon discharge at the delivery point is suitable for adequate placement and consolidation in place.

Truck agitators shall be loaded not to exceed the manufacturer's rated capacity. They shall maintain the mixed concrete in a thoroughly mixed and uniform mass during hauling.

Bodies of non-agitating hauling equipments shall be so constructed that leakage of the concrete mix, or any part thereof, will not occur at any time, and they shall be self-cleaning during discharge.

For zero slump concrete to be laid by paver, concrete will be allowed to be hauled in open trucks. However concrete hauled in open-top vehicles shall be protected during hauling against rain or exposure to the sun for more than twenty (20) minutes when the ambient temperature exceeds twenty five (25) degree C.

No additional water shall be incorporated in to the concrete during hauling or after arrival at the delivery point.

The rate of discharge of mixed concrete from truck mixer agitators shall be controlled by the speed of rotation of the drum in the discharge direction with the discharge gate fully open.

When a truck mixer or agitator is used for transporting concrete to the delivery point, discharge shall be completed within one hour, or before two hundred fifty (250) revolutions of the drum or blades, whichever comes first, after the introduction of cement to the aggregates. Under conditions contributing to quick stiffening of the concrete, or when the temperature of the concrete is thirty (30) degree C or above, a time less than one hour will be required except when retarder is used in which case it shall be one (1) hour.

When non-agitating hauling equipment is used for transporting concrete to the delivery point, discharge shall be completed within one hour after the addition of the cement to the aggregates. Under conditions contributing to quick stiffening of the concrete, or when the temperature of the concrete is thirty (30) degree C or above, the time between the introduction of cement to the aggregates and discharge shall not exceed forty five (45) minutes.

12.2 Delivery

The organization supplying concrete shall have sufficient plant capacity and Transportation vehicles to ensure continuous delivery at the rate required. The rate of the delivery of concrete during concreting operations shall be such as to provide for the proper handling, placing, and finishing of the concrete. The rate shall be such that the interval between batches shall not exceed twenty (20) minutes. The methods of delivering and handling the concrete shall be such as will facilitate placing with the minimum rehandling and without damage to the structure of the concrete.

12.3 Retempering

The concrete shall be mixed only in such quantities as are required for immediate use and any concrete that has developed initial set shall not be used. Concrete that has partially hardened shall not be retempered or remixed.

13. HANDLING AND PLACING CONCRETE

13.1. General

In preparation for the placing of concrete all saw dust, chips and other construction debris and extraneous matter shall be removed from inside the formwork, and struts, stays and braces serving temporarily to hold the forms in correct shape and alignment, pending the placing of concrete at their locations, shall be removed when the concrete placing has reached an elevation rendering their services unnecessary. These temporary members shall be entirely removed from the forms and not buried in the concrete.

No concrete shall be used that does not reach its final position in the forms within the time stipulated above under item "Hauling and Delivery of Mixed Concrete".

Concrete shall be placed so as to avoid segregation of the materials and the displacement of the reinforcement. The use of long troughs, chutes and pipes for conveying concrete to the forms shall be permitted only on written authorization of the Engineer. In any case the Engineer will

reject the use of equipment for concrete transportation that will allow segregation loss of fines, or in any other way will have a deteriorating effect on the concrete quality.

Open troughs and chutes shall be of metal or metal lined; where steep slopes are required the chutes shall be equipped with baffles or be in short lengths that reverse the direction of movement.

All chutes, troughs and pipes shall be kept clean and free from coatings of hardened concrete by thoroughly flushing with water after each run; water used for flushing shall be discharged clear off the structure.

When placing operations would involve dropping the concrete more than one and half (1½) meters, it shall be conveyed through sheet metal or other approved pipes. As far as practicable the pipe shall be kept buried in the newly placed concrete. After initial set of the concrete the forms shall not be jarred and no loading of any kind shall be placed on the ends of projecting reinforcement bars.

The concrete shall be placed as nearly as possible to its final position and the use of vibrators for extensive shifting of the mass of fresh concrete will not be permitted.

13.2. Pneumatic Placing

Pneumatic placing of concrete will be permitted only if authorized by the Engineer. The equipments shall be so arranged that no vibration will occur that might damage freshly placed concrete.

Where concrete is conveyed and placed by pneumatic means, the equipment shall be suitable in kind and adequate in capacity for the work.

The machines shall be located as close as practicable to the work. The discharge lines shall be horizontal or inclined upwards from the machine. At the conclusion of placing the concrete, the entire equipment shall be thoroughly cleaned.

13.3. Pumping

The placing of concrete by pumping will be permitted only if specified in the Special Provisions or if authorized by the Engineer. The equipment shall be so arranged that no vibration will occur that might damage freshly placed concrete.

Where concrete is conveyed and placed by mechanically applied pressure the equipment shall be suitable in kind and adequate in capacity for the work. The operation of the pump shall be such that a continuous stream of concrete without air pockets is obtained. When pumping is completed the concrete remaining in the pipeline if it is to be used, shall be ejected in such a manner that there will be no contamination of the concrete or separation of the ingredients. After this operation, the entire equipment shall be thoroughly cleaned.

13.4. Placing Concrete Under Water

Concretes shall not be placed under water except where inevitable in which case approval must be sought from the Engineer and the work carried out under his immediate supervision. In this case the method of placing shall be as hereinafter specified.

Concrete deposited under water shall be Class A concrete with a minimum cement content of three hundred fifty (350) Kg per cubic meter of concrete.

The slump of concrete shall be maintained between ten (10) and fifteen (15) cm. To prevent segregation it shall be carefully placed in a compact mass, in its final position, means of a tremie, a bottom-dump bucket, or other approved means, and it shall not be disturbed after being placed. Water must not be allowed to flow past the fresh concrete surface.

A tremie shall consist of a tube having a diameter of not less than 25 cm constructed in sections having flanged couplings fitted with gaskets with a hopper at the top. The tremie shall be supported. So as to permit free movement of the discharge end over the entire top surface of the work and so as to permit rapid lowering when necessary to retard or stop the flow of concrete.

The discharge end shall be closed at the start of work so as to prevent water entering the tube and shall be completely submerged in concrete at all times; the tremie tube shall be kept full to the bottom of the hopper. When a batch is dumped into the hopper, the flow of concrete shall be induced by slightly raising the discharge end, but always keeping it in the placed concrete. The flow shall be induced until the work is completed.

When the concrete is placed with a bottom-dump bucket, the top of the bucket shall be open. The bottom doors shall open freely downward and outward when tripped. The bucket shall be completely filled and slowly lowered to avoid backwash. It shall not be dumped until it rests on the surface upon which the concrete is to be deposited and when discharged shall be withdrawn slowly until well above the concrete.

Dewatering may proceed when the concrete seal is sufficiently hard and strong. All laitance or other unsatisfactory material shall be removed from the exposed surface by scraping, chipping or other means, which will not injure the surface of the concrete.

13.5. Compaction

Concrete, during and immediately after placing shall be thoroughly compacted, except lean concrete under footings and concrete deposited under water. Concrete in walls, beams, columns, etc shall be placed in horizontal layers not more than thirty (30) centimeters thick except as hereinafter provided. When less than a complete layer is placed in one operation, it shall be terminated in a vertical bulkhead. Each layer shall be placed and compacted before the preceding layer has taken initial set to prevent injury to the green concrete and avoid surfaces of separation between the layers. Each layer shall be compacted so as to avoid the formation of a construction joint with a preceding layer, which has not taken an initial set.

The compaction shall be done by mechanical vibration. The concrete shall be vibrated internally unless special authorization of other methods is given by the Engineer or is provided herein. Vibrators shall be of a type, design, and frequency approved by the Engineer. The intensity of vibration shall be such as visibly to affect a mass of concrete with a 3 cm slump over a radius of at least half a meter. The Contractor shall provide a sufficient number of vibrators to properly compact each batch immediately after it is placed in the forms. Vibrators shall be manipulated so as to thoroughly work the concrete around the reinforcement and embedded fixtures and into the corners and angles of the forms and shall be applied at the point of placing and in the area of freshly placed concrete. The vibrators shall be inserted into and withdrawn from the concrete slowly. The vibration shall be of sufficient duration and intensity to compact the concrete thoroughly but shall not be continued at any one point to the extent that localized areas of grout are formed. Application of vibrators shall be at points uniformly spaced and not farther apart than twice the radius over which the vibration is visibly effective. Vibration shall not be applied directly to the reinforcement or to sections or layers of concrete that have hardened to the degree that the concrete ceases to be plastic under vibration. It shall not be used to make concrete flow in the forms over distances so great as to cause segregation and vibrators shall not be used to transport concrete neither in the forms nor in troughs or chutes.

Vibration shall be supplemented by such external vibrator as is necessary to ensure smooth surfaces and dense concrete along form surfaces and in corners and locations impossible to reach with the normal vibrators.

13.6. Concrete in Hot & Cold Weather

a) Concrete in hot weather

Concreting shall be avoided in timely hot weather and shall be done only in better part of the day. It should be particularly avoided in dry, hot and windy weather for member with large surface areas exposed to the weather. Aggregate shall be carefully stored under shelter and shall be sprinkled with cold water from time to time to check high temperature.

Water, to be used for concreting, shall be carefully used and, if necessary, crashed ice shall be added to bring the temperature as low as 70° F in order to at resulting temperature of concrete is not above 100° F. Excess of water shall not be added and the specified water of cement ratio shall be maintained.

b) Concert In Cold Weather

When depositing concert is unavoidable at a temperature below 36° F, precaution shall be taken to ensure that the concert shall have a temperature of at least 40° F, at the time of placing of concert. The temperature of concert shall be maintained at not less than 40° F until it is thoroughly hardened. Sand or other material shall not be used in the prevention of freezing and no frozen materials or material containing ice or snow shall be used.

13.7. Surface finishes/ rendering

a) General

Concrete surface finishes shall be classified as follows:

Bridge Deck Surface Finish
Sidewalk Surface Finish
Ordinary Surface Form Finish
Class 1 Surface Form Finish

The bridge deck surface finish shall be given to the surface of the bottom Slabs of all box type underpass structures.

The requirements for sidewalk surface finish apply to the surface of the bottoms labs in box culverts, except that the acceptable variation from a three-meter straightedge shall be 10 mm, and brooming shall be omitted.

The ordinary surface form finish shall be the final finish applied to all Surfaces after removal of forms, unless otherwise specified or called for on the drawings.

The Class 1 surface form finish shall be applied only where specified or as required by the Engineer when the ordinary surface finish did not produce the required smooth, even surface of uniform texture and appearances.

b) Bridge Deck Surface Finish

A smooth riding surface of uniform texture, true to the required grade and cross-section, shall be obtained on all bridge roadway decks. The Contractor may use hand tools, or finishing machines or a combination of both, conforming to the requirements specified herein for finishing bridge roadway deck concrete.

Finishing of concrete placed in bridge decks shall consist essentially of compacting and striking off the surface of the concrete as placed and floating with longitudinal floats the surface so struck off.

The placing of concrete in bridge roadway decks will not be permitted until the Engineer is satisfied that the rate of producing concrete will be sufficient to complete the proposed placing and finishing operations within the schedule time, that experienced finishing machine operators and concrete finishers are employed to finish the deck, that fogging equipment and all necessary finishing tools and equipment are on hand at the site of the work and in satisfactory condition for use. Finishing machines shall be set up sufficiently in advance of use to permit inspection by the Engineer during the daylight hours before each Pour.

The adjustment and operation of deck finishing machines shall be verified by moving the machine over the full length of the deck section to be placed and traversing the float completely across all end bulkheads before placement of concrete is begun.

Unless adequate lighting facilities are provided by the Contractor, the placing of concrete in bridge decks shall cease at such time that finishing operations can be completed during daylight hours.

Rails for the support and operation of finishing machines and headers for hand-operated strick-off devices shall be completely in place and firmly secured for the scheduled length for concrete placement before placing of concrete. Rails for finishing machines shall extend beyond both ends of the scheduled length for concrete placement to a sufficient distance that will permit the float of the finishing machine to fully clear the concrete to be placed. Rails or

headers shall be adjustable for elevation and shall be set to elevations, with allowance for anticipated settlement, camber, and deflection of false work, as required to obtain a bridge roadway deck true to the required grade and cross-section. Rails or headers shall be of a type and shall be so installed that no springing or deflection will occur under the weight of the finishing equipment and shall be so located that finishing equipment may operate without interruption over the entire bridge roadway deck to be finished.

Rails or headers shall be adjusted as necessary to correct for unanticipated settlement or deflection which may occur during finishing operations.

Should settlement or other unanticipated events occur, which in the opinion of the Engineer would prevent pouring of bridge deck conforming to the requirements of these specifications, placing of deck concrete shall be discontinued until corrective measures satisfactory to the Engineer are provided. In the event satisfactory measures are not provided prior to initial set of the concrete in the affected area, the placing of concrete shall be discounted and a bulkhead installed at a location determined by the Engineer. All concrete in place beyond the bulkhead shall be removed.

Unless otherwise permitted by the Engineer, bridge deck concrete shall be placed in a uniform heading approximately parallel to the bridge pier or bent caps. The rate of placing concrete shall be limited to that which can be finished before the beginning of initial set except that concrete for the deck surface shall not be placed more than (03) meters ahead of strick off.

After the concrete has been placed, compacted and consolidated, the surface of the concrete shall be carefully struck off by means of a hand operated strick board operating on headers, or by a finishing machine operating on rails. A uniform deck surface true to the required grade and cross-section shall be obtained.

Following strike off, the surface of the concrete shall be floated longitudinally. In the event strick-off is performed by means of a hand-operated strike board, two (2) separate hand-operated float boards for longitudinal floating shall be provided. The first float shall be placed in operation as soon as the condition of the concrete will permit and the second float shall be operated as far back of the first float as the workability of the concrete will permit.

In the event the strike off is performed with a finishing machine, longitudinal floating of the concrete shall be performed by means of a hand-operated float board or a finishing machine equipped with a longitudinal wooden float. The longitudinal wooden float on the finishing machine shall have a length of not less than two and half (2.5) meters nor more than three and half (3.5) meters. When both strike off and longitudinal floating are to be performed by finishing machines, one machine, with operator, shall be used for strike off and a second machine, with a second operator, shall be used for longitudinal floating. Longitudinal floating may be performed with the same finishing machine that is used for strike off provided that the length of deck unit being placed is not more than 10 meters and the strike off operation is completed for said deck unit before the condition of the concrete requires that longitudinal floating be started.

Finishing machines used for strike off having a wheel base 1.8 meters or less shall be followed by 2 separate hand-operated float boards for longitudinal floating. All the provisions in this item pertaining to hand-operated float boards shall apply to the 2 separate float boards for longitudinal floating.

Longitudinal floats, either hand-operated or machine-operated, shall be used with the long axis of the float parallel to the center line of the bridge roadway. The float shall be operated with a combined longitudinal and transverse motion planning off the high areas and floating the material removed into the low areas. Each pass of the float shall lap the pervious pass by one-half the length of the float. Floating shall be continued until a smooth riding surface is obtained.

In advance of curing operations, the surface of the concrete shall be textured by brooming with a stiff bristled broom or by other suitable devices, which will result in uniform scouring. The operation shall be performed at a time and in a manner to produce a hardened surface having a uniform texture.

Hand-operated float boards shall be from three and half (3.5) to five (5) meter long, ribbed and trussed as necessary to provide a rigid float and shall be equipped with an adjustable handle each end. The float shall be wood, not less than two and half (2.5) cms thick and from ten (10) cm to twenty (20) cm wide. Adjusting screws spaced as not to exceed 60 cms on centers shall be provided between the float and the rib. The float board shall be maintained free of twist and true at all time.

Hand-operated float boards shall be operated from transverse finishing bridges. The finishing bridges shall span completely the roadway area being floated & a sufficient number of finishing bridges shall be provided to permit operation of the floats without undue delay. Not less than two (2) transverse finishing bridges shall be provided when hand-operated float boards are used. When a finishing machine is used for longitudinal floating, one finishing bridge equivalent to the transverse finishing bridge specified herein shall be furnished for use by the Engineer.

All finishing bridges shall be of rigid construction and shall be free of excessive wobble and springing when used by the operators of longitudinal floats and shall be easily moved.

The finished surface of the concrete shall be tested by means of a straightedge three (3.0) meter long. The surface shall not vary more than three (3) mm from the lower edge of the straightedge. All high areas in the hardened surface in excess of three (3) mm as indicated by testing shall be removed by abrasive means. After grinding by abrasive mean has been performed, the surface of the concrete shall not be smooth or polished. Ground areas shall not be of uniform texture and shall present neat and approximately.

Where the concrete of the bridge deck is to be covered by bituminous surfacing, earth or other cover, two and half 2.5 cms or more in thickness, the surface of the concrete shall not vary more than nine (9) mm from the lower edge of the three (3) meter straightedge Bridge deck surface under the curbs, railings and sidewalk shall be struck off to the same plane as the roadway and left undisturbed when future widening is shown on the plans.

c) Sidewalk Surface Finish

After the concrete has been placed it shall be compacted and the concrete shall be struck off by means of a strike board, floated with a wooden or cork floating and finish with a broom. An approved edging tool shall be used on all edges and at all expansion joints. Brooming shall be transverse to the line of traffic and if water is necessary, it shall be applied to the surface immediately in advance of brooming. The surface shall not vary more than six (6) mm under a three-meter straightedge, and the finished surface shall be free of blemishes.

d) Ordinary Surface from Finish

Ordinary surface finish shall consist of filling holes or depressions in the surface of the concrete, repairing all rock pockets, removing stains and discoloration visible from traveled ways. Ordinary surface finish shall be applied to all concrete surfaces either as a final finish or preparatory to the Class 1 finish. On surfaces, which are to be buried underground or surface, which are enclosed, such as the cells of box girders; the removal of fins will not be required.

Except as provided herein, all from bolts and any metal placed for the convenience of the Contractor shall be removed to a depth of at-least two and half (2.5) cms below the surface of the concrete. All rock pockets and other unsound concrete shall be removed. The resulting holes or depression shall be cleaned and filled with mortar. From bolts projecting into the cells of box girders need not be removed unless permanent access is provided into the cells, in which case such bolts shall be removed flush with the surface of the concrete. Mortar used to fill bolt holes shall consist of one part cement and two parts sand. Other depressions and pockets shall be filled with either packed mortar or air blown mortar as directed by the Engineer. Mortar shall be cured in conformance with the requirements in item 401:3.8 (c) "Curing Structures"

If rock pockets or holes in the opinion of the Engineer, are of such an extent or character as to affect the strength of the structure materially or to endanger the life of the steel reinforcement, he may declare the concrete defective and require the removal and replacement of the portions of the structure affected.

e) Class 1 Surface from Finish

Class 1 surface finish shall consist of finishing the surfaces of the structure as necessary to produce even surfaces of uniform texture and appearance, free of unsightly bulges, depression and other imperfections. The degree of care in building forms and character of materials used in form work will be a contributing factor in the amount of additional finishing required to produce even surfaces of uniform texture and appearance, free of unsightly bulges, depressions and other imperfections, and the Engineer shall be the sole judge in this respect.

After completion of the ordinary surface finish, areas which do not exhibit the required smooth, even surface of uniform texture and appearance shall be sanded with power sanders or other approved abrasive means until smooth, even surfaces of uniform texture and appearance are obtained. The use of power carborundum stones or disks will be required to remove bulges and other imperfections.

Class 1 surface finish shall not be applied until a uniform appearance can be obtained.

Class 1 surface finish may be required to be applied as the final finish for the following surfaces, unless otherwise directed by the Engineer.

- i. All form finish surfaces of bridge super-structures except the under surfaces between girders and the inside vertical surfaces of T girders.
- ii. All surfaces of bridge piers, columns and abutments, and retaining walls above finished ground and to at least three tenth (0.3) meter below finished ground.
- iii. All surfaces of open spandrel arch rings, spandrel columns and abutment walls.
- iv. All surfaces of pedestrian undercrossing, except floors and surfaces to be covered with earth.
- v. Surface above finished ground of culvert headwalls, end walls and retaining walls.
- vi. Surface inside of culvert barrels having a height of one and half (1.5) meters or more for a distance inside the barrel at least equal to the height of the culvert.
- vii. All surface of railings.

f) Surface Rendering

All faces of concrete which are to come in contact with backfill or pavement materials shall be applied two coats of hot bitumen of approved quality, before placing any material around concrete.

14. FINISHING

- a). Finishing of concrete surfaces shall be performed only by skilled workmen and as directed by the Engineer. Formed surfaces upon or against which backfill or concrete is to be placed will require no treatment after form removal except for the removal and repair of defective concrete and for the specified curing. Unformed surfaces that will be covered by backfill or by concrete shall be finished by sufficient leveling and screeding to produce an even uniform surface.
- b). A hard steel trowel finish shall be applied to unformed surfaces that will be exposed or subjected to the action of flowing later. Floating and trowelling shall be started as soon as the screeded surface has stiffened sufficiently, and shall be the minimum necessary to produce a surface that is free from screed marks and is uniform in texture.

15. CURING AND PROTECTION

- a). The concrete shall be kept continuously wet by the application of water for a minimum period of Seven (07) days after the concrete has been placed. Beginning immediately after placement, concrete shall be protected from premature drying, excessively hot or cold

temperatures and mechanical injury and shall be maintained with minimal moisture loss at a relatively constant temperature for the period necessary for hydration of the cement and hardening of the concrete. Cotton mats, burlaps, rugs, carpets or earth or sand blanket, may be used as a curing medium to retain the moisture. The entire surface of the concrete shall be kept damp by applying water with a nozzle that so atomizes the flow that a mist and not a spray is formed.

At the expiration of the curing period the concrete surface shall be cleared of all curing mediums.

- b). Surface exposed to the air may be cured by the application of an imperious membrane (i.e. curing compound) with prior written approval from the Engineer.
- c). For concrete surfaces not in contact with forms, one of the following procedures shall be applied immediately after completion of placement and finishing:
 - Ponding or continuous sprinkling.
 - Application of absorptive mats or fabric kept continuously wet.
 - Application of sand kept continuously wet.
- d). Curing shall be continued minimum Seven (07) days in the case of all concrete except concrete with Rapid-hardening Portland Cement for which the minimum period shall be three (03) days.

16. TEST OF CONCRETE QUALITY

Samples of fine and coarse aggregate to be used shall be selected by the Engineer. It shall be the responsibility of the Contractor to designate the source or sources of aggregate and obtain the necessary samples and submit them for testing at least thirty (30) days before actual concreting operations are to being.

Samples of aggregates shall be obtained and tested in accordance with the following standard AASHTO methods.

i)	Sampling aggregates	T-2
ii)	Sieve analysis	T-27
iii)	Amount of material passing the no. 200 sieve	T-11
iv)	Organic impurities	T-11
v)	Mortar Strength	T-71
vi)	Sodium sulphate soundness	T-104
vii)	Friable particles	T-112
viii)	Abrasion loss	T-96
ix)	Specific Gravity	T-84
x)	Absorption	T-85
xi)	Production of Plastic Fines	T-210
xii)	Fineness Modulus	T-27
xiii)	Sand Equivalent	T-17
xiv)	Potential Reactivity of Carbonate Rocks for Concrete Aggregate (Rock Cylinder Method)	ASTM C 586
xv)	Potential Alkali Reactivity of Cement Aggregate Combinations (Morta-Bar Method)	ASTM C 227
xvi)	Potential Reactivity of Aggregates (Chemical Methods)	ASTM C 289

No aggregate for testing during the production of concrete shall be sampled at the discharge gates of the bins feeding the weight hopper. The Contractor, at his expense, shall provide safe and suitable facilities for obtaining the samples no concreting work on the project will be permitted until the Engineer signifies in writing his approval. Following the performance of the necessary tests, on all materials involved in making concrete.

17. MEASUREMENT AND PAYMENT

17.1. General

Except otherwise specified herein or elsewhere in the Contract Documents no separate measurement and payment will be made for the under mentioned specified works related to the relevant items of the Bills of Quantities but shall not be limited to the following. The cost thereof shall be deemed to have been included in the quoted unit rate of the respective items of the Bills of Quantities.

17.2. Plain and Reinforced Concrete

a) Measurement

Concrete shall be measured as executed but no deduction shall be made for the following:-

- Volume of any steel embedded in the concrete
- Volume occupied by water pipes, conduits etc. not exceeding 25 sq.cm. each in cross sectional area.
- Voids not exceeding 0.10 Sq.M. in work given in Sq.M. If any void exceeds 0.10 Sq.M. total void shall be deducted.
- Void, which are not to be deducted as specified above, refer only to opening or vents which are wholly within the boundary of measured areas. Openings or vents which are at the boundary, measured areas shall always be subject to deductions irrespective of size.

Concrete work shall be classified and measured separately as listed under items of Bills of Quantities.

Measurement of acceptably completed works of plain and reinforced cement concrete will be made on the basis of concrete placed and compacted in position within the neat lines of the structure as shown on the drawings or as directed by the Engineer.

b) Payment

Payment will be made for the acceptable measured quantity of plain and reinforced cement concrete on the basis of unit rate quoted in the Bill of Quantities and shall constitute full compensation for all the works related to the items.

STEEL REINFORCEMENT

1. SCOPE

The work under this section of specifications consists of furnishing, cutting, fabricating, bending and placing steel reinforcement and Welded wire, fabric of the type, size, shape and grade required in accordance with these specifications, in concrete structures or elsewhere as shown on the drawings and special provisions or as directed by the Engineer.

2. APPLICABLE STANDARDS

Latest editions of the following Pakistan, British and ASTM Standards are relevant to these specifications wherever applicable.

Pakistan Standard

PS 241	Tensile Testing of Steel
PS 244	Bend test for Steel
PS 580	Rolled deformed Steel bars (intermediate grade) for concrete reinforcement.
PS 605	Rolled deformed steel bars (hard grade) for concrete reinforcement.
PS 606	Rolled formed Steel bars (structural grade) for concrete reinforcement.
PS 607	General technical delivery requirement for steel

British Standard

BS 693	General requirements for Oxy-acetylene welding of mild steel
BS 785	Hot rolled bars and hard drawn wire for the reinforcement of concrete
BS 1856	General requirement for the metal arc welding of mild steel
BS 4449	Hot rolled steel bars for reinforcement of concrete
BS 4461	Cold worked steel bars for reinforcement of concrete
BS 4466	Bending dimensions and scheduling of bars for the reinforcement of concrete

ASTM Standard

A 305	Minimum requirement for the deformations of deformed steel bars for concrete reinforcement
A 615	Deformed billet steel bars (Grades 40 and 60) for concrete reinforcement – AASHTO M-30.

In addition to the above, the latest editions of other Pakistan Standards, British standards, American Concrete Institute Standards, American Society for Testing and Materials Standards and other standard as may be specified by the Engineer for Special Material and construction are also relevant.

3. MATERIAL AND SIZE OF BARS

- a). Reinforcement for concrete shall conform to the respective Pakistan, British, ASTM, or other Standards as specified in the Drawings and in the Contract Documents or as may be specified by the Engineer.
- b). Unless otherwise specified, all plain reinforcing bars shall comply with the requirements of BS 4449 for plain mild steel bars and shall have a minimum characteristic strength of 280 MPa (40000 psi)
- c). Unless otherwise specified, all deformed reinforcing bars shall comply with the requirements of BS 4461 for deformed cold worked new stock billet steel bars and shall have minimum characteristic strength of 460 MPa (60000 psi).
- d). If the reinforcement is supplied by the Employer, the Contractor should inform the Employer of his requirements much before its use in construction.
- e). Reinforcement of all types is to be stored at on site in an approved manner so as to avoid damage.

- f). If the reinforcement is supplied by the Employer, the Contractor should report immediately on receipt of any consignment, any deviation from the standard of three enforcement bars beyond those allowed in respective standards. If the Engineer directs, the Contractor shall test the samples of reinforcement at his cost and submit to him the test report.
- g). Steel wire mesh reinforcement shall conform to requirements of ASTM Designation A 185 - 64 or BS 4483, 1969: Standard Specifications for Welded Steel Wire Fabric for concrete reinforcement. It shall be used where shown on the Drawings.
- h). Reinforcement shall be free from all loose or flaky rust and mill scale, or coating, including ice, and any other substance that would reduce or destroy the bend. Reduced sections steel reinforcement shall not be used.

4. DELIVERY & STORAGE

Steel reinforcement bars shall be kept in bundles firmly secured and tagged. Each bar or bundle of bars shall be identified by marks stamped on hot or cold or painted on or by any other means, The identifying marks shall contain the following information:

- ♦ Name of the producer or his trade.
- ♦ Standard to which the bars have been manufactured.
- ♦ The class type and strength
- ♦ The diameter
- ♦ The number of the test certificate

The method of storage shall be approved by the Engineer. Reinforcing bars shall be stored in racks or platforms above the surface of ground and shall be protected free from scaling, rusting, oiling, coatings, damage, contamination and structural defects prior to placement in works. Bars of different diameters and grades of steel reinforcement shall be kept separately.

5. BAR BENDING SCHEDULES

The Contractor shall prepare bar bending schedules of all the reinforcing steel bars and these bar bending schedules shall be submitted to the Engineer for his approval. The Contractor shall obtain approval of the bar bending schedules atleast one month prior to the actual execution of the works at site.

6. FABRICATING, BENDING & PLACING

- a). All metal reinforcement shall be free from loose mill scale, loose rust, mud, oil, grease, or other harmful matter immediately before the concrete is placed.
- b). Reinforcement is to be accurately placed as shown in the drawings, and secured against displacement by using 16 gauges GI wire ties or suitable slips at intersections and supported from the formwork by using concrete, metal or plastic chairs and spacers or hangers of an approved pattern. Where concrete blocks are used for ensuring the cover, they shall be made of mortar not leaner than 1 part of cement to 2 parts of sand.
- c). Bars used for concrete reinforcement shall be fabricated in accordance with the dimensions shown in the bar bending schedule approved by the Engineer.
- d). The cutting tolerance for all bars shall be ± 1 inch.
- e). Where an overall or an internal dimension of a bent bar is specified in the schedule, the bending tolerance, unless otherwise stated, shall be as in Table - 1.
- f). Bent bar reinforcement shall cold bent to the shapes shown on the drawings bars shall be bent around a pin having the following diameters (D) in relation to the diameter of the bar (d):

Strips & columns tie bars	$D = 4 \times d$	
Other bars having	$D = 5 \times d$	$D = 10 \times d$

$d < 3.5 \text{ cm } (1\frac{3}{8} \text{''})$ (No. 11 bars)
 $d > 3.5 \text{ cm } (1\frac{3}{8} \text{''})$

Table
Bending Tolerances

Dimensions of bent bars		Tolerance	
Over	Up to & including	Plus	Minus
Inch	Inch	Inch	Inch
--	36	2	2
36	72	2	4
72	--	2	10

- g). Vertical bars in columns shall be offset at least one bar diameter at lapped splices. To ensure proper placement, templates shall be furnished for all column dowels.
- h). Reinforcement shall not be bent or straightened in a manner that will injure the material.
- i). No bars shall be bent twice in the same place, nor shall they be straightened after bending.
- j). Unless permitted, by Engineer, reinforcement shall not be bent after being partially embedded in hardened concrete.
- k). Bars which depend for their strength on cold working shall not be heated for any reason. Other kinds of reinforcement larger than 40 mm in dia: may be bent by the use of heat at cherry - red heat (not exceeding 840 Bars) bent shall not be cooled by quenching.
- l). No splice of reinforcement shall be made except as shown on the working drawings.
- m). Welding shall be permitted for bars only under suitable conditions and with suitable safeguards in accordance with BS 693, BS 1856, or AWS D 12.1, provided the type of reinforcement bar has the required welding properties. Tack welding may be used to fix in position bars that cross each other, only with prior approval of the Engineer.
- n). Exposed reinforcement intended for bonding with future extensions is to be effectively protected from corrosion. Protection is also to be provided to reinforcement partly built into concrete where the exposed part is to be built into later concrete.
- o). No concreting is to be carried out until the reinforcement has been checked and approved by the Engineer.
- p). All detailing shall be done as per ACI standards ACI - 315 and ACI - 318.
- q). Minimum Concrete clear cover for reinforcing steel shall be as follows:

Structural Members	Minimum Cover, inch
a) Concrete cast against and permanently exposed to earth	3 inch
b) Concrete exposed to earth or weather:-	
Bar Dia > 20 mm	2 inch
Bar Dia > 16 mm	1.6 inch
c) Concrete not exposed to weather or in contact with ground	
Slabs, Walls	0.8 inch
Beams, Columns (PPrimary Reinforcement)	1.6 inch

All reinforcing steel shall be held firmly in place before and during the placing of concrete by means of wires and supports adequate to prevent displacement during the course of construction.

7. MEASUREMENT & PAYMENT

7.1 General

Except otherwise specified herein or elsewhere in the Contract Documents, no separate measurement and payment will be made for providing and installing chairs, supports, hooks, spacers, binding wires and laps not shown on Drawings including wastage and rolling margin, the cost of which shall be deemed to have been included in the quoted unit rate of the respective items of the Bill of quantities.

7.2 Measurement

All measurements of acceptably completed works of reinforcement shall be made in linear dimensions end to end according to the cut lengths shown in bar bending schedules approved by the Engineer and converted into theoretical weight as per schedules.

7.3 Payment

Payment will be made for acceptable measured quantity of reinforcement on the basis of unit rate quoted in the Bills of Quantities and shall constitute full compensation for all the works related to the item.

BLOCK WORKS

1. SCOPE

These specifications cover the supply of materials manufacture and workmanship of concrete blocks intended to be used for the construction of block walling, partitions, facings, claustra, etc, required for the project.

2. MATERIALS

2.1 Cement

Cement for solid or hollow blocks are mortar shall be ordinary Portland cement ASTM Designation: C 150-74.

2.2 Aggregate

Aggregate for solid and hollow concrete blocks shall conform to the requirements for fine aggregates in the "CONCRETE "section.

2.3 Water

Water to be used in blocks shall conform to the requirements specified for water in the "CONCRETE "section.

2.4 Additives

Additives shall only be used with the Consultant's written instructions and shall be from approved manufacturers and used strictly in accordance with the manufacturer's instructions.

2.5 Wall Ties

Wall ties shall be galvanized wire butter-fly type to BS1243:1978 and DD140 Part 1:1986 and DD140:Part2:1987.

2.6 Damp Proof Course

Damp proof courses and the like shall be a high strength preformed self-adhesive membrane 1.5mm thick comprising of rubber/bitumen compound and three layers cross laminated HDPE carrier film obtained from an approved manufacturer.

3. MANUFACTURE OF CONCRETE BLOCKS

Aggregate shall be so sized, graded, proportioned and thoroughly mixed in a bath mixer with such proportions of cement and water as to produce homogeneous concrete mixture. However, in no case shall the proportion of cement in the mixture be less than five (5) standard bags (each weighing 50 kgs) per cubic meter of concrete.

Concrete blocks shall be obtained from an approved local factory. The blocks shall be press moulded in approved moulds and vibrating pressure machine with a minimum of 28000 cycles per minute.

Hollow concrete blocks shall comply with the following requirements: -

Compressive Strength at Twenty Eight (28) Days Over Cross-Sectional Area:-

- a) **Load Bearing Walls**
60 kgs/cm² average of 12 blocks
50 kgs/cm² minimums for any block
- b) **Non-Load-Bearing Walls.**
30 kgs/cm² averages of 12 blocks
25 kgs/cm², minimum for any block

4. MORTAR

Mortar shall be prepared in the following proportions with the addition of the minimum quantity of clean water for workability.

Cement and sand mortar (1:3) mix, shall be composed of one part cement to three parts of sand by volume.

Cement mortars shall be used within thirty (30) minutes after mixing. Hardened mortars shall not be used in the work and shall, upon the request of the Consultant, be immediately removed from the site.

5. WORKMANSHIP

All block work shall be set out and built to the respective dimensions, thickness and heights shown on the Drawings and / or as instructed by The Consultant.

The blocks shall be well soaked before being used and the tops of walls left off shall be wetted before work is recommended. All blocks shall be well buttered with mortar before being laid and all joints shall be thoroughly flushed up as the work proceeds. All joints shall be in uniform manner and shall not exceed 10 mm., no one portion being raised more than 1.00 meter above another at one time, and wall of partition necessarily left at different levels must be raked backfill perpend quains, internal and external angles, etc. shall be kept strictly true and square and the whole properly bonded together and leveled round. All block work shall be plumbed vertically.

The surface of the walls and partitions prepared for plastering shall have the joints raked out 20 mm from the face of the wall to form key for the plaster.

All block walls shall be bonded to reinforced concrete columns by means of wall ties, complying in all respects with B.S 1243 latest edition. The ties shall be minimum 200 mm, long of which 100 mm shall be embedded in the reinforced concrete column and the remainder set into the block wall at the rate of two (2) ties per meter. Partitions shall be bonded to main walls by toothing at every fourth coursed into main walls to a depth of not less than 100 mm.

All walls and partitions shall be properly cured by sprinkling water for a period not less than three (3) days after completion of laying the course.

PILING

1. DESCRIPTION

This work shall consist of performing all operations in connection with furnishing of cast in place piles and load testing of specific piles to obtain the specified bearing value complete in place and strictly in accordance with these specifications and as shown on the drawings.

When test piles and load tests are required, the data obtained from such load tests will be used in conjunction with other available subsoil information to determine the number and lengths of piles to be furnished. The Engineer will not prepare the itemised list of piles for any portion of the foundation area until all loading tests representative of that portion have been completed.

The requirements herein are minimum. Strict compliance with these minimum requirements will not relieve the Contractor of the responsibility for adopting whatever additional provisions may be necessary to insure the successful completion of the work.

The kind and type of piles shall be as shown on the Drawings and/or as specified. No alternate types or kinds of piling shall be used, except with the written approval of the Engineer each time an alternate type or kind is proposed for use in a particular structure.

2. MATERIAL REQUIREMENTS

2.1 Cast-in-Place Concrete Piles

Cast-in-place concrete piles shall consist of one of the following two types as shown on the Drawings and/or as specified:

- Concrete cast in drilled holes.
- Steel shells or tubes driven permanently to the required bearing value and filled with concrete. The steel shell or tube may or may not act as a permanent load-carrying member.

Concrete for cast-in-place piles shall be Class A or as shown on the drawing and meet all the requirements unless otherwise specified. The concrete shall be cast in dry holes or shells/pipes.

Reinforcement, if called for, shall conform to the requirements under "Steel Reinforcement".

Steel shells/pipes shall be of sufficient strength and rigidity to permit driving to the required bearing value or depth without injury. The steel shells may be cylindrical or tapered, step-tapered or a combination, and either plain circular or fluted. The different types shall conform to the corresponding ASTM Standards. The minimum average tensile strength of the steel shall be 3,500 kg/cm² (50,000 psi).

When called for on the Drawings or by the Engineer, the pile shells or tubes shall be factory coated on both interior and exterior surfaces by red lead paint conforming to AASHTO M-72, or as otherwise stated. The coatings shall not interfere with producing satisfactory welds when assembling pile sections.

3. CONSTRUCTION REQUIREMENTS

3.1 Location and Site Preparation

Piles shall be used where indicated on the Drawings or as directed by the Engineer.

All excavation for the foundation in which the piles are to be driven shall be completed before the driving is begun, unless otherwise specified or approved by the Engineer. After driving is completed, all loose and displaced materials shall be removed from around the piles by hand excavation, leaving clean solid surfaces to receive the concrete of the foundations.

3.2 Determination of Pile Length

The criteria for pile length and bearing capacity will be determined by the Engineer according to the results from test piling and load tests. The piles shall be driven to such depths, that the bearing loads indicated on the Drawings are obtained.

The criterion for pile length may be one of the following:

- a) Piles in sand and gravel shall be driven to a bearing value determined by use of the pile driving formula or as decided by the Engineer.
- b) Piles in clay shall be driven to a depth as directed by the Engineer. However, the bearing value shall be controlled by the appropriate pile driving formula if called for by the Engineer.
- c) Piles shall be driven to refusal on rock or hard layer when so directed by the Engineer.

The Contractor shall be responsible for correct pile lengths and bearing capacities according to the criterion or criteria given by the Engineer.

3.3 Piles Cast in Place

Piles cast in place shall consist of concrete cast in drilled holes or in steel shells or pipes driven to the required bearing.

a) Boring Procedure

The method and equipment of boring generally either the dry method, wet method, temporary casing method or permanent casing method shall be one which maintains stability, verticality or batter (as shown on the Drawing) of the wall and base of borehole by the use of temporary casing and/or bentonite slurry. However, it will be the responsibility of the contractor to suggest the method and the equipment to be used by him for boring for pile for the approval of engineer. Notwithstanding the approval of Engineer the contractor shall not be relieved of his responsibility for his proposed method.

All holes shall be drilled to the tip elevation shown on the Drawings, unless otherwise specified or approved by the Engineer. Rejected boreholes shall be filled with lean concrete by contractor at his expense.

The method shall be such that allows soil samples to be taken and in site soil test, (if required) to be carried out during or ahead of boring operations. The method/procedure used in execution of borehole and other operations shall not be such as to cause vibrations resulting in damage to completed or partially completed piles or to adjacent structures, services or other property. The procedure shall not be such as to cause harmful loosening or softening of soil outside the pile that has to be filled with concrete. The equipment used for execution of borehole shall be adequate to ensure that each pile penetrates to the required founding level.

b) Use of Casing

Suitable casings shall be furnished and placed when required to prevent caving of the holes before concrete is poured. Casing, if used in drilling operations shall be removed from the hole as concrete is poured unless otherwise specified. The bottom of the casing shall be maintained not less than fifty (50) cm below the top of the concrete during withdrawal and pouring operations unless otherwise permitted by the Engineer. Separation of the concrete during withdrawal operations shall be avoided.

• Temporary Casing Method

The temporary casing of appropriate diameter for locating the pile and piloting the borehole shall be pitched at the exact locations as given on the drawings to ensure that the casing when sunk is within the specified tolerances. The casing shall be sunk to sufficient depth by approved methods. The depth shall be at least sufficient to prevent the ingress of alluvium or other loose materials into the bore when executed below the bottom level of the casing. In addition, the depth shall be such as the contractor considers necessary for the stability of the casing and for temporary works system during construction in general and

for the following conditions and operations in particular during all conditions of river current which may occur during the period of works:

- a) Open temporary casing to ensure against blow-in of soil.
- b) Concrete of the pile, until temporary casing is extracted.

- **Safety of Casing**

The contractor shall take all such measures and provide such strengthening and bracing as is necessary and to the approval of the engineer to ensure that the temporary casing is not disturbed, overturned, over-stressed or under-eroded in any condition of temporary casing shall be such that it will not disturb the freshly cast concrete and/or permanent lining and/or reinforcement.

Where the use of temporary casing is approved for the purpose of maintaining the stability and over-rapid withdrawal of the boring tools which could lead to excessive removal of soil and water and disturbance of the surrounding ground and when boring through any permeable stratum (including silt), the water level in the boring shall be maintained between one (1) meter and two (2) meters above the external water level, unless the engineer directs otherwise.

The temporary casings shall be free from significant distortion and should be of uniform cross sections throughout each continuous length. During concreting they shall be free from encrusted concrete or any internal projections, which might prevent the proper formation of the piles.

- **Permanent Casing Method**

The permanent casing construction method shall be used when required by the plans. This method consists of driving or drilling a casing to a prescribed depth before excavation begins. If full penetration cannot be attained, the Engineer may require either excavation of material within the embedded portion of the casing or excavation of a pilot hole ahead of the casing until the casing reaches the desired penetration. In some cases, over-reaming to the outside diameter of the casing may be required in order to advance the casing.

The casing shall be continuous between the elevations shown on the plans. Unless shown on the plans, the use of temporary casing in lieu of or in addition to the permanent casing shall not be used except when authorized by the Engineer in writing.

After the installation of the casing and the excavation of the shaft is complete, the casing shall be cutoff at the prescribed elevation and the reinforcing steel and shaft concrete placed within the portion of the casing left in place.

c) Bentonite Slurry

Where the use of bentonite slurry is approved for the purpose of maintaining the stability of the walls and base of bore, the contractor's proposals in accordance with (sub clause vi) and Methodology submitted under sub clause (i) hereof shall include details of the slurry. These shall include inter-alia:

- The source of the bentonite.
- The constitution of the slurry.
- Specific gravity, viscosity, sheer strength and PH value of slurry.
- The methods of mixing, storing, placing, removal and re-circulating the slurry, and
- The provision of stand-by equipment.

Tests shall be carried out to ensure that the proposed constitution of the slurry is compatible with the ground water. Proposals for the construction and physical properties of the slurry shall include average, minimum and maximum values. The specific gravity for the slurry shall not be less than one and three hundredth (1.03) in any case at any time. The contractor shall use additives where necessary, to ensure the satisfactory functioning of the slurry. A manufacturer's certificate shall be provided to the Engineer by the Contractor for each consignment of bentonite brought on site.

Notwithstanding the Manufactures Certificate the Engineer may ask the contractor to arrange and conduct tests for specific gravity, PH value and viscosity or any other test which he deems is necessary to check the quality of bentonite.

The test apparatus and Test Method shall be those given in;

“Recommended practice”

Standard by American Petroleum Institute, New York City 1957, reference, API RP29 Section I, II & IV.

The contractor shall promptly make the arrangement for such test, without any additional cost to the project.

- **Precautions**

The Contractor shall control the bentonite slurry so that it does not cause a nuisance either on the site or adjacent waterways or other areas. After use it shall be disposed in a manner to the approval of the Engineer.

The level of the bentonite slurry shall be maintained in the bore during excavation of pile, so that the internal fluid pressure always exceeds the external water pressure.

If chiselling is used when boring through hard strata or to overcome obstructions, the stability of the excavation shall be maintained by methods acceptable to the Engineer.

d) Excavation from Bore holes

The soil and debris from inside the pile bore holes shall removed, by bucket augur or circulating bentonite slurry provided that no jetting at the foot of the boreholes shall be permitted. Methods of excavation, which in the opinion of the Engineer may damage the permanent lining of the pile, shall not be employed.

Should the excavation reveal any soil stratum below the bottom of a pile which is in the opinion of the Engineer, unsuitable for supporting the loads that will be imposed on it, the Contractor shall remove all such sub soil stratum to the satisfaction of the Engineer and shall lengthen the pile if necessary and cost of any such lengthening shall be paid as per this contract.

Excavation shall be carried out as rapidly as possible in order to reduce to a minimum the time in which any strata are exposed to the atmosphere, bentonite slurry or water. In any case, a pile shall not remain unfilled with concrete for period exceeding eighteen (18) hours after completion of borehole.

The materials from pile excavation shall be disposed so that the same does not interfere with any part of the permanent works of this project, in neat and workmanlike manner.

e) Samples and Tests

The Contractor shall take soil samples as given below or as directed by the Engineer to the designed tip elevation of the pile and shall carry out insitu Standard Penetration tests within, and ahead of borehole on the line of vertical axis of the pile at these locations after one and half (1.5) meter interval. The costs of tests and collection of samples shall be deemed to be included in the unit rates quoted by the Contractor. Each disturbed sample shall, as far as possible, be truly representative of the grading of insitu soil at the point from which it is taken, without contamination by other material. It shall be approximately five (5) kg in weight and shall be placed in a strong airtight container immediately after its removal from the sampler. The container shall be sealed as soon as the sample has been placed in and shall be taken to the site laboratory for grading, moisture content and Atterberg Limits tests.

The apparatus and procedure for the Standard Penetration Test shall be in accordance with the provisions of ASTM D 1586 Penetration Test and split-barrel sampling of soils to ASTM D 1587 thin-walled sampling of soils, (except insofar as any such provision may conflict with other requirements of the contract).

f) Limitations of Boring Sequence

Piles shall be constructed in such a manner and sequence as to ensure that no damage is sustained by piles already constructed in adjacent position. The contractor shall submit to the engineer for his approval a program showing sequence of construction of various piles.

g) Piling Reinforcement

The reinforcement for each pile shall be assembled and securely tied by means of binding wire and by welded reinforcement rings of twenty five (25) mm diameter bar as shown on the drawings, in such a manner as to form a rigid cage.

The required concrete cover to the reinforcement shall be maintained by suitable spacers securely attached to the reinforcement and of sufficient strength to resist damage during handling of the reinforcement cage into the pile. The distance between the spacers shall be such that the required cover is maintained throughout and that there is no displacement of the reinforcement cage in the course of the concreting operation.

Should the Contractor prefer to lower the reinforcement cage assembly into the borehole in sections, he may do so provided the same lapping requirements as for assembly on the ground are followed, namely, the longitudinal reinforcement shall be lapped as shown on the drawings and the spiral reinforcement shall be doubled over the lap zones. Spacers maintaining concrete cover shall be located immediately below and above the laps at 4 points spaced around the cage.

3.4 Concreting of Piles

The following particular requirements shall be observed.

i) Materials

Comprehensive strength of concrete in piles shall be of Class-A using minimum 400 kg. Cement in 1m³ of concrete for piles or otherwise as shown on the drawings.

Suitable re-trader, plasticiser may be added as approved by the Engineer.

The Contractor shall submit the details of proposed additive for approval, which shall be approved after laboratory trial mix results. The dosing of re-traders shall ensure initial setting time of not less than five (5) hours corresponding to the ambient temperature at which the concreting is proposed to be carried out.

ii) Commencement of Concreting

Prior to placing any concrete:

- a) Any heavy contaminated bentonite slurry, which could impair the free flow of concrete from the tremie pipe, shall be removed.
- b) Any loose or soft material/soil shall be removed from the bottom of the bore by methods acceptable to the Engineer.

The Contractor shall not proceed with the concreting of the pile until the Engineer gives specific permit to do so after satisfying himself of the:

- Adequacy of the Contractors equipment and arrangement.
- Proficiency of his personnel.
- Cleanliness of the borehole.
- Length of the borehole in accordance with Drawings/Instructions.

Contractor shall have a suitable lighting arrangements at all times for inspecting the entire length of the shells, pipe or hole before placing the reinforcing steel or concrete.

The Engineer may desire that prior to the concreting a pile, sample of slurry be taken from the base of the borehole using an approved sampling device and its specific gravity determined.

iii) Placing of Concrete

The tremie shall be of not less than two hundred and fifty (250) mm diameter made of water-tight construction. The means of supporting the tremie shall be such as to permit the free movement of the discharge end in the concrete in the pile. The tremie pipe shall be fitted with travelling plug, which shall be placed at the top of the pipe before charging the tremie pipe with concrete as barrier between the concrete and water or bentonite slurry, so as to prevent water or bentonite slurry entering the tube and mixing with the concrete. The tremie shall be carefully lowered into the borehole so that the end of the tube shall rest at about one hundred and fifty (150) mm above the bottom of the borehole, with reinforcement in the borehole, and the hopper end of the tremie tube shall be filled with concrete as aforesaid. It shall be slightly raised so that when the concrete reaches the bottom it flows out of the lower end of the tube, and fills the bottom of the borehole. Thereafter, the rate of withdrawal of the tremie shall be gradual so as to ensure the end of the tremie pipe is always one and half (1.5) meters below the top of the concrete in the borehole. An allowance shall be made for the top five hundred (500) mm of concrete in borehole during concreting being unsatisfactory. When the next batch is placed in the hopper the tremie shall be slightly raised but not out of the concrete at the bottom, until the batch discharges to the bottom of the upper. This operation shall be controlled by calculating the volume of concrete required to fill one linear meter of pile and then by measuring the rate of withdrawal of the tube corresponding to the volume of the batch in the hopper. The flow shall then be retarded by lowering the tube. The depth of the concrete in borehole shall be measured at intervals to keep a constant check that the tremie pipe bottom is immersed in concrete.

Concreting in each pile shall be carried out in a continuous operation without stoppages until the pile has been completed.

If the bottom of the tremie pipe ceases to be immersed in the body of the concrete in the pile and the seal is broken, concreting shall cease immediately and such remedial measures as the Engineer may accept or direct shall be carried out. The Contractor shall take precautions to ensure that the concrete is free of voids and shall prevent the entry of water and/or collapse of soil into concrete. If any soil or other deleterious or extraneous materials fall into any pile excavation prior to or during concreting, it shall be removed immediately.

Concreting shall continue until the concrete has reached an elevation five hundred (500) mm higher than the designated pile cut off level shown on the drawings, or as otherwise directed by the Engineer.

The concrete shall be placed in one continuous operation from tip to cut-off elevation and shall be carried out in such a manner as to avoid segregation. The method of placing the concrete and the consistency (slump) shall conform to the requirements of Item 401 or to the satisfaction of the Engineer.

No shell or pipe shall be filled with concrete until all adjacent shells, pipes or piles within a radius of three (3) M or five (5) times the pile diameter, whichever is greater, have been driven to the required resistance.

After a shell or pipe has been filled with concrete, no pile shall be driven within (7) meters thereof until unless seven (7) days have elapsed.

iv) Withdrawal of Temporary Casing

If the method of construction involves partial withdrawal of temporary casing as concreting proceeds, a sufficient head of concrete shall be maintained above the bottom of the temporary casing to ensure that no voids are formed within the pile and to prevent the entry of ground water and to prevent the collapse of soil into the concrete.

If such entry or collapse should occur, the temporary casing shall be re-driven before the concrete has set and all defective concrete shall be removed or the construction of the pile shall be abandoned, in which case the provision of the clause herein which refers to "Defective Piles" shall apply.

The withdrawal of the temporary casing shall be carried out before the adjacent concrete has taken its initial set.

The method and timing of withdrawal must be such as to ensure that the space between the pile and the surrounding ground shall be filled with concrete.

3.5 Steel Shells and Pipes

After being driven and prior to placement of reinforcing steel and concrete therein, the steel shells or pipes shall be examined for collapse or reduced diameter at any point. Any shell or pipe which is improperly driven or broken or shows partial collapse to such an extent as to materially decrease its bearing value will be rejected. Rejected shells or pipes shall be removed and replaced, or a new shell or pipe shall be driven adjacent to the rejected one. Rejected shells or pipes which cannot be removed shall be filled with lean concrete by the Contractor at his expense.

3.6 Splicing of Piles

Splicing of piles, when permitted by the Engineer, shall be made as shown on the Drawings and as specified with materials having same quality and characteristic as for the material used for the pile itself. For Steel Shells and Pipes, the Splicing shall be as under:

If the ordered length of the steel pipe, or shell is insufficient to obtain the specified bearing value, an extension of the same cross-section shall be spliced to it. Unless otherwise shown on the Drawings, splices shall be made by butt-welding the entire cross-section to form an integral pile using the electric arc method. The sections connected shall be properly aligned so that the axis of the pile will be straight. Piles bent or otherwise injured shall be rejected.

3.7 Cutting of Piles

Top of piles shall be embedded in the concrete footing as shown on the Drawings.

Concrete piles shall, when approved by the Engineer, be cut-off at such a level that at least 5 cm of undamaged pile can be embedded in the structure above. If a pile is damaged below this level, the Contractor shall repair the pile to the satisfaction of the Engineer. The longitudinal reinforcement of the piles shall be embedded in the structure above to a length equal to at least 40 times the diameter of the main reinforcing bars. The distance from the side of any pile to the nearest edge of the footing shall not be less than twenty (20) cm.

When the cut-off elevation for the steel shell or pile for a cast-in-place concrete pile is below the elevation of the bottom of the pile cap, the pile may be built up from the butt of the pile to the elevation of the bottom of the cap by means of a reinforced concrete extension, if approved by the Engineer.

3.8 Defective Piles

Any pile with defects such as damaged during cast in situ, placed out of its proper location, incapable or partially capable of permanently carrying the load which it is intended to carry, driven below the elevation fixed by the Drawing or by the Engineer, due to the immature setting of the concrete in the pile or due to caving/collapse of the borehole fully or partially, or due to any cause of which Engineer shall be sole judge to determine shall be corrected at the Contractor's expense by one of the following methods approved by the Engineer:

- (a) A second pile shall be driven or cast adjacent to the defective pile.
- (b) The pile shall be spliced or built up as otherwise provided herein or the underside of the footing lowered to properly imbed the pile.

The Contractor shall undertake such additional tests/works as the Engineer may specify to provide additional foundations to supplement the defective piles and so modify the structure to be supported as to ensure that load will be transferred safely to the additional foundations of existing pile. The Contractor shall be responsible for the cost of such additional functions and tests and/or of the extra work carried out in such modification to the structure.

3.9 Test Piles

Test piles which are shown on the Drawings or ordered by the Engineer shall conform to the requirements for piling as specified and shall be so located that they may be cut-off and become a part of the completed structure.

Test piles to be load tested in accordance with sub-Section 407.3.8 shall be driven in locations determined by the Engineer. These piles shall not be utilised in the structure unless otherwise directed.

Any pile, which after serving its purpose as a test pile is found unsatisfactory for utilisation in the structure, shall be removed if so ordered by the Engineer, or if approved by the Engineer it shall be cut-off below the ground line and footings, but such approval does not in any way relieve the Contractor of his responsibilities.

Test pile shall generally be driven with the same equipment that is to be used for driving foundation piles. When required, the ground shall be excavated to the elevation of bottom of the footing before the test pile is driven.

3.10 Load Tests

Load tests shall be made where specified and/or where called for by the Engineer. Unless otherwise permitted by the Engineer the load tests shall be completed before the remaining piles in the same structure are cast.

In any case no pile should be subjected to load test unless the concrete has attained the specified strength at 28 days, which shall be evidenced through the concrete cylinder compressive strength.

Load tests shall be made by the methods approved by the Engineer. The Contractor shall submit to the Engineer detailed plans of the loading system and apparatus he intends to use at least 3 weeks in advance. The apparatus shall be so constructed as to allow the various increments of the load to be placed gradually without causing vibration to the test piles. Tension anchor piles if used, shall be of a design and driven to a depth satisfactory to the Engineer. Steel shells or piles whose walls are not of adequate strength to withstand the test loading when empty, shall have the required reinforcement and concrete placed before loading for a load test is applied. Through cylinder tests it is ensured that the concrete has attained the desired strength at 28 days.

***Load cell/hydraulic pump pressure and dial gauges should be preferably re-calibrated at site and certified calibration curve shall accompany each device*.**

Suitable approved apparatus for determining accurately the load on the pile and the settlement of the pile under each increment of load shall be supplied by the Contractor. The apparatus shall have a working capacity of two (2.0) times the design load for the pile being tested. Reference points for measuring pile settlement shall be sufficiently removed from the test pile to preclude all possibility of disturbance.

All pile load settlements shall be measured by adequate devices, such as gauges, and shall be checked by means of an Engineer's level. Increments of deflection shall be read just after each load increment is applied and at 15 minute intervals thereafter. The safe allowable load shall be considered as 50 percent of the load which, after 48 hours of continuous application, has caused not more than 6 mm of permanent settlement, measured at the top of the pile. This maximum settlement should not increase by continuous application of the test load for 60 hours or longer (AASHTO).

The pile load test should be carried out in accordance of ASTM D1143 – 81 (re-approved 1987). The load should be applied using the standard loading procedure as described Clause 5.1 of ASTM 1143 and interpreted below:

Sr. No.	Increment No.	Load % of Design Load	Time	Sr. No.	Decrement No.	Load % of Design Load	Time
1	1	25	2 hours *	9	1	175	20 minutes
2	2	50	2 hours *	10	2	150	20 minutes
3	3	75	2 hours *	11	3	125	20 minutes
4	4	100	2 hours *	12	4	100	20 minutes
5	5	125	2 hours *	13	5	75	20 minutes
6	6	150	2 hours *	14	6	50	20 minutes
7	7	175	2 hours *	15	7	15	20 minutes
8	8	200	24 hours *	16	8	0	20 minutes

*** The load should be maintained in each increment until the rate of settlement is not greater than 0.25mm/hr, but not longer than 2 hrs.**

The full test load shall remain on the test pile for not less than 48 hours. If pile failure occurs continue jacking until the settlement for equal to 15% of the pile diameter. Full report should be submitted by the Contractor in accordance with ASTM 1143.

The test pile shall be considered satisfactory provided the load-settlement curve shows no signs of failure and the permanent settlement at the top of the pile after completion of the test does not exceed 6.00 mm.

The pile may be considered to have failed when the total permanent settlement exceeds 6 mm.

3.11 Pile Records

The Contractor shall keep records of all piles installed. A copy of the records shall be given to the Engineer within 2 days after each pile is installed. The record form to be used shall be approved by the Engineer. The pile records shall give full information on the following:

Cast-in-Place Piles

Pile type and nominal dimensions.

Date of boring commenced, level reached each day and date of casting.

Soil samples taken from pile boring operation and soil test results.

Strata and ground water encountered with levels, description shall be in accordance with B.S.C.P. 2001.

Length of finished pile and tip elevation.

Dia of borehole.

Elevation of the bottom of boreholes.

Date of placing concrete; theoretical and actual quantities of concrete used in pile.

Lengths and diameter of temporary casing and permanent lining and the elevation of the tip of temporary casing and of permanent lining.

Details of Reinforcement.

Details of penetration during boring operation or driving of steel shell (driving records as for driven piles).

Quality, consistency and other test results on concrete.

Time interval between boring or driving and concreting.

Any other relevant information.

ARCHITECTURAL WORKS

EXCAVATION AND EARTH WORK

1. GENERAL

The Contractor shall Judge for himself the nature of the ground and shall be fully responsible for ascertaining all necessary information concerning permanent water table, periods of rainfall, flooding of the site and all matters affecting the excavations and foundation work including the need to excavate in rock should this occur.

The methods of excavation, which the contractor desires to use, shall be at the sole discretion of the Contractor. The use of explosives may be permitted only with the Engineer's written consent and permission of police.

The contractor shall report to the Engineer when excavations are ready to receive foundation concrete and shall obtain consent before depositing concrete.

In the event of excavations being made larger than the sizes directed by the Engineer, the contractor shall fill in the excavated void to the correct profile with mass concrete as described under section "Concrete work" hereinafter, at his own expense and as directed by the Engineer.

The final 150 mm depth of all excavations shall be taken out by hand unless allowed by the Engineer otherwise and the bottom leveled and rammed immediately prior to placing concrete.

2. NEW AND EXISTING LEVELS

Before work commences on the site the Contractor shall carry out survey of the levels of the site and obtain the verification of the Engineer of these levels. Levels shall be taken one grid to be agreed by the Engineer and the Contractor shall produce a drawing of these levels for record purposes.

3. POOR GROUND

Loose soil, bad ground or cavities met within any part of the excavations for foundations of structures shall be excavated to a solid formation and filled to foundation level with hardcore or other approved material properly compacted to the Engineers approval, beneath all strip footings the excess excavated material shall be replaced with concrete

4. SHORING EXCAVATION

The Contractor shall, to the satisfaction of the Engineer, shore the sides of excavations for structures, trenches and pits to prevent them from slipping or falling. Should any slips fail or settlement nevertheless occur they should be made good by the Contractor at his own expense with selected fill or with mass concrete as may be directed by the Engineer.

In removing shoring from the sides of excavations, care shall be taken to avoid bringing loads on to any concrete until it has hardened sufficiently to carry such loads.

Timber or other material used for shoring the sides of excavations shall be removed as the work proceeds except when ordered to be left, in by the Engineer.

The Contractor shall, not later than four weeks before commencing any excavation, submit to the Engineer for inspection calculations and working drawings for the proposed scheme for strutting and retaining the sides of the excavations and shall not proceed with the appropriate sections of the works until receipt of the Engineer's written consent.

The receipt of such consent shall not relieve the contractor of any of his duties and responsibilities under the Contract.

5. BACK FILLING

Foundation trenches, column bases and the like, are to be backfilled with selected materials, well rammed and consolidated by hand tamping to the satisfaction of the Engineer in layers not exceeding 200 mm thick, and sufficiently watered during the tamping to achieve maximum consolidation.

6. DISPOSAL OF SURPLUS EXCAVATED MATERIAL

Surplus excavated material not required for backfilling or for maintaining the made up levels shall be removed from the site to a soil heap approved by the Municipality, by the Contractor.

7. TRIMMING OF SLOPES

The slopes of cutting and embankments shall be trimmed by hand or by approved mechanical means to uniform batters is shown on the drawings or as directed by the Engineer. A tolerance of plus or minus 100 mm measured at right angles to the batter will be permitted.

Any rock or boulder appearing in the face of a cutting shall be trimmed back to within the tolerance specified above and in addition any such rock or boulder which in the opinion of the Engineer is unstable shall be completely removed and the resulting void filled with compacted material to the approval of the Engineer.

8. KEEPING EXCAVATIONS FROM WATER

The Contractor shall be responsible for keeping all excavations free from water from whatever cause arising and shall provide such pumping capacity and other temporary works as may be necessary for this purpose. All rates for excavation to include for all pumping and dewatering necessary to achieve the works.

The Contractor shall make good at his own expense any damage that may result from his failure to keep the excavations free from water. Due regard should be given to the stability of the neighboring structures.

9. COMPACTED FILL

Compacted fill shall comprise non-plastic granular material or well graded hardcore or “Sabkha” from an approved source.

- a) The granular fill is to be compacted using a vibrating compactor of not less than 1.5 tons. The fill to be compacted in layers 150 mm thick. Compaction shall continue until there is no creep of the hardcore ahead of the roller, all voids are filled and the surface is smooth and even. Pressing of the surface with lines is permitted if required. See separate specification for compacting road sub-bases.
- b) The Sabkha is to be compacted in a like manner, but is to be rolled wet.
- c) The hardcore shall be blended with a 50 mm bed of sand well tamped to produce a dense level surface.

10. POLYTHENE SHEETING

Polythene sheeting where shown on the drawings shall be Visquenn 1000 super D.P.M. Sheeting manufactured by approved supplier in rolls and laid by rolling over the prepared base at the levels and in the areas shown on the drawings. Where a joint is necessary at the side or end of a sheet this shall be a double welt folded joint made by placing the edges together and folding over twice. The joint shall be prevented from opening prior to concreting by blocks placed at intervals on top of the joint. Particular care shall be taken in forming the joint between horizontal and vertical sheets where the concrete requires to be wrapped so that a continuous damp proof membrane is formed.

The contractor shall protect the sheets from damage during laying and subsequent operations and shall replace all damaged sheets to the satisfaction of the Engineer.

11. COMPACTION PROCEDURE

The procedure for compacting the existing sub-grade and any filling material is subject to the approval by the Engineer and shall be generally as outlined below. The adoption of the procedure outlined below and the giving of approval by the Engineer shall not relieve the Contractor of his responsibility in providing compacted soil in accordance with sub-clause a below.

- a) Each layer of profile shall be compacted to give a minimum density of 90% of the Maximum Dry Density throughout the whole thickness of the layer or the top 300 mm of existing sub-grade. The maximum dry density being established by B.S Standard Tests (or AASHO equivalent tests). (B.S test to BS 1377:1975 – Test No. 9 AASHO test to AASHO T 160 – 61).
- b) After carrying out the grading, leveling, scarifying, pulverizing, etc., of the soil layer to be compacted as per specifications, the Contractor shall add the necessary amount of water to permeate the pulverized soil in the quantity required, all in accordance with the instructions of the Engineer.
- c) The soil shall then be thoroughly mixed after adding each lot of water so as to achieve homogenous moisture content in the whole thickness of the layer.
- d) Before compacting, sample from the pulverized soil will be taken and tested, in order to check the natural moisture content and to bring it within +2 and or -4 per cent of the Optimum Moisture Content. When the material is within this moisture range, it shall be primarily leveled in order to commence earth compaction.
- e) After primary leveling referred to above, compaction shall be commenced by means or approved rollers depending on the type or soil being compacted in order to obtain the required density.
- f) The rolling shall be carried out until the soil reaches the required density. If the surface is super-elevated, rolling shall commence from lower side and continue to the higher side. In order to compensate for the amount of water lost in evaporation in the course of compaction, additional quantities of water shall be added as required.
- g) The surface shall thereafter be leveled longitudinally and transversely by motor graders and finally rolled to achieve uniform compaction free from undulations, soft spots and depressions all in conformity with the allowable tolerances for evenness of surfaces.
- h) Compaction of sloped sections of embankments and ditches shall be carried out as hereinafter specified with regard to pulverization of soil, addition of the necessary water. Shaping and compaction to the required degree of compaction and the required design sections.
- i) The Contractor's attention is drawn to the necessity of providing all machinery, equipment and attachments required for the effective and efficient shaping and compaction of these sloped sections.

12. ACCEPTANCE OF EARTHWORK AND FILLING

Acceptance of earthwork and filling shall be determined by testing the degree of compaction and the levels and evenness of surface of the approved materials. Such testing and acceptance shall be performed as the work progresses. Each layer shall be tested and approved prior to progressing with additional layers. The engineer shall have the right to retest any areas at any time and the Contractor shall be responsible for correcting and deficiencies.

13. DEGREE OF COMPACTION

The maximum dry reference density and optimum moisture for earthwork materials shall be determined by the BS or AASHTO tests by using the methods described in Clause A–5 above subject to approval of the Engineer.

The density and thickness of any compacted layer shall be ascertained by obtaining a specimen from the soil after completing compaction In accordance with the B.S or AASHO Specifications and control curves of dry density compaction and optimum moisture content established for each type of soil material being used. In case this specimen does not conform with the required density and thickness, additional tests may be taken to determine' the limits of the failing area, after which the contractor shall scarify, pulverize, water, compact and level the layer again, and if necessary, add new material (or otherwise modify the existing material) at his own expense, all in accordance with specifications, until the required result is obtained. The Contractor shall allow in

his daily work program enough time to permit the performance and checking of the above tests, all in accordance with the instructions of the Engineer and under his guidance.

14. LEVELS AND EVENNESS OF SURFACES

The Engineer shall test the levels and evenness of the sub-grade surface and/or of finished surface to ascertain their conformity with the drawings and specifications.

The Contractor shall make available to the Engineer a four-meter straight edge & crown template of sturdy & approved design & necessary labour to assist in checking operation.

15. SOIL INVESTIGATION

This Clause shall apply to soil mechanics as well as foundation engineering to the Site where the works are being constructed, to determine the suitability of the foundation proposed for the works to be constructed on the site.

The Contractor should carry out his own soil investigation to see the soil conditions and its bearing capacity and this should be priced in the Preliminaries Section of the bill of quantities.

15.1 Digital Submittals of Soil Investigation

All reports and drawings shall be submitted in digital form (CD or similar), as follows:

- a) The Contractor shall provide on recordable CD media an identical reproducible copy of the report. This shall be in a PDF format to be directly readable as a single file.
- b) The Contractor shall provide in digital format all relevant information in an editable Excel spreadsheet form able to be directly convertible in "KEY AGS3". The format spreadsheet will be made available from the Engineer.

The Contractor should make himself aware of the following software to ensure the relevant information and content is provided.

- KEY AGS 97
- HOLEBASE 3
- KEYHOLE 5
- KEYHOLE VETRA

The Contractor shall provide in editable format the following in CD media:

- *.doc (WinWord) All report text.
- *.jpeg All borehole records.
- *.jpeg All laboratory test data sheets and results.
- *.jpeg All core photography
- *.dwg (AutoCAD V14) Miscellaneous report drawings

METAL WORKS

1. MATERIALS

1.1 General Provisions

- i. When a precise grade or alloy of metal is not specified the Contractor shall obtain the metal from an approved specialist supplier or fabricator who shall be informed by the Contractor of the particular application of the metal within the Works and it shall be the Contractor's responsibility to obtain the correct material suited to its application in the Works.
- ii. All materials and components shall be the best of their respective kind, to the dimensions shown on the drawings and where applicable sections shall be in accordance with the relevant B.S., DIN or approved equivalent standard.

1.2 Steel

- i. Where the terms "steel" or "mild steel" are used it shall mean steel to BS 4: part 1, BS 1449, BS 4360 or BS 4848 and shall be Grade 43A unless specified otherwise.
- ii. Stainless steels shall be austenitic steel unless specified otherwise and shall be in accordance with BS 1449; Part 2 and finish shall be as specified on the drawings. (eg. Dull Polish, Mirror Polish etc.).

1.3 Aluminum

- i. The term "aluminum" shall mean 'wrought aluminum alloys for general engineering purposes' in accordance with the BS 1470 - 1475 series and 'cast aluminum' shall be aluminum cast by permanent mould or gravity die techniques to BS 1490 using LM6 alloy.
- ii. The Contractor shall submit samples of components to the Engineer for approval together with test certificates which show that the components possess the following characteristics.

MECHANICAL PROPERTIES	
Cupping test to DIN 53156	9 mm
Bend test to DIN 53152	Less than 5 mm
Reverse impact to ASTM 27944-69	100-150 CM/KG
Indentation hardness to DIN 3153	More than 100
Pencil hardness	2H
Cross cut test to DIN 53151	Gt.0

CONTINUOUS HEAT RESISTANCE	
After 1000 hours at 120°C	Slight yellowing of white shades

CORROSION AND WEATHERING TEST	
Humidity test to DIN 50017 on zinc phosphated steel sheet	No change after 500 hours
Salt spray test to ASTM B 117 on zinc phosphated steel sheet	No loss of adhesion after 20 rounds
Weathering in Florida (USA) and industrial climate	Excellent results

CHEMICAL RESISTANCE		
Test Medium	Time	Result
Premium petrol (gasoline)	10 minutes	No change
Ethanol	10 minutes	No change
Toluene	10 minutes	No change
Butylacetate	10 minutes	No change
Trichloroethylene	10 minutes	Softening
Acetone	10 minutes	Softening
Hydrochloric acid, 10%	4 weeks	No change
Sulfuric acid, 10%	4 weeks	No change
Acetic acid, 10%	4 weeks	No change
Soda solution, 1%	4 weeks	No change
Nitric acid, 1%	4 weeks	No change
Fuel oil	4 weeks	No change
Ammonia, 10%	4 weeks	No change
Caustic soda lye, 10%	4 weeks	Detached

1.4 Surface Finish

- i. In addition to specific surface finishes, the contractor shall where necessary adequately treat or seal the permanently hidden parts of metal work from deterioration and corrosion (excluding standard hollow sections).
- ii. Mill finish aluminum will not be accepted unless specified or to the Engineer's written approval or to be subsequently decorated.
- iii. The design of metal components shall comply with the requirements of BS 4479 in as much as they are applicable to the specific component and where a British Standard exists for the component it shall also be complied with.
- iv. All fixings shall be of materials compatible with the component being fixed and where dissimilar metals are used adequate precautions, such as coating or sleeving, shall be taken to prevent electrolytic corrosion.
- v. All nuts and bolts shall be adequately protected from corrosion and all exposed bolts including carpenters and joiners metalwork are to be capped with an approved dome headed nut.

1.5 Protective Coatings and Finishes

1.5.1 Primers

Section of primers shall be in accordance with BS 5493 and shall comply to BS 2523, BS 3098 or BS 4652.

1.5.2 Galvanizing

Where steel is referred to as 'galvanized' galvanizing shall be applied by Hot Drip process to BS 729 and BS 2989 and unless specified otherwise shall be 85mm (6.0g/m²)

1.5.3 Anodizing

- i. Where indicated on the drawings or specified elsewhere aluminum shall be anodized in accordance with BS 1615 Grade AA25 and BS 3987 to the colour and finish approved by the Engineer.
- ii. Anodizing shall be by the "Anoloc" process to give 25 micron minimum depth and a certificate of anodizing shall be submitted to the Engineer.
- iii. Sections shall be anodizing before cutting into length to suit the fittings dimensions.

1.5.4 Polyester Powder Coating

- i. Powder coatings shall comply to BS 6496 or BS 6497 as applicable to the material to be coated.
- ii. Polyester powder coating shall be to a minimum film thickness of 100 microns and carried out by an approved specialist to the specified colour.
- iii. Steel to receive polyester powder coatings shall be first galvanized in accordance with Clause 1.5.2.
- iv. Aluminum sections to receive polyester powder coating shall be first cleaned, degreased and primed with two-pack each primer.

1.5.5 Painting

When described on the drawings/schedules painting of metalwork shall be in accordance with Section 7 of this specification.

2. COMPONENTS

2.1 General Requirements

- i. All components shall be obtained from an approved supplier/ fabricator and the contractor shall submit to the Engineer for his approval a complete set of shop drawings indicating dimensions, materials, components, fixings etc, prior to commencement of fabrication.
- ii. The design of metal components shall comply with the requirements of BS 4479 in as much as they are applicable to the specific component, and where a British Standard exists for that component it shall also be complied with.
- iii. The shop drawings referred to in clause.2.1. (i) above shall conform to the design, dimensions and general descriptions as shown on the drawings/schedules and as specified.
- iv. The aluminum work shall be designed and fixings designed and anchored so that the component will not be distorted nor the fasteners overstressed as a result of thermal movement of the component, the glazing or the adjacent structure.
- v. All fixings shall be of materials compatible with the component being fixed and where dissimilar metals are used adequate precautions, such as coating or sleeving, shall be taken to prevent electrolytic corrosion.
- vi. All nuts and bolts shall be adequately protected from corrosion and all exposed bolts including Carpenters and Joiners metalwork are to be capped with an approved dome headed nut.

2.2 Aluminum Windows, Doors and Screens

- i. Aluminum windows shall be manufactured to BS 4873 and tested to BS 4315 Part 1 to comply with sever exposure rating as defined in BS 6375 Part 1.
- ii. The Contractor shall obtain from the window manufacturer all design calculations in respect of wind loading for external windows and screens and submit them to the Engineer for approval.
- iii. Aluminum framed sliding glass doors shall be in accordance with BS 5286.
- iv. Glazing shall be installed at the factory at the time manufacture in accordance with Section 12 of this specification.
- v. All main frame sections, door members, stiles etc. shall not be less than 2.5 mm thick. Covers, flashings, glazing clips etc. shall not be less than 1.5 mm thick.

- vi. Glazed sections shall be provided with high quality neoprene gasket and polypropylene woolpiles which fit within the relevant groove in the profile and be integral with the extrusion and system.
- vii. All fixings, ironmongery, locks and locking devices, fly screens, glazing, weather-stripping etc. necessary for the proper and intended function of the component shall be included with the component and shall be allowed for within the Contractors Tender and shall be easily replaceable.
- viii. Ironmongery to such fabricated components shall be of comparable quality to the ironmongery used elsewhere and suited to the proposed operation of the component and the component shall be suitably strengthened, lapped and modified to receive the ironmongery and the finish shall match the finish of the units.
- ix. When shown on the drawings/schedules or specified, particular requirements for ironmongery and any other integral parts of the component shall be included.
- x. All frames, angles, channels and the like shall be non-ferrous and fixed with countersunk aluminum screws or as indicated on the drawings/schedules all of which shall be finished to match exactly the colour and finish of the adjacent aluminum components and sections or to the specified finish/colour.
- xi. Fly screens, where indicated, shall be of fibre glass coated PVC and the screen assembly shall be integral with the window / door framing.

2.3 Workmanship

- i. All metal shall be undertaken in accordance with sound engineering and smithy practice and as much metalwork as possible shall be undertaken in properly equipped workshops with site work restricted to fixing and other operations that cannot be undertaken prior to delivery to site.
- ii. All finished components shall be wrapped, taped or otherwise protected with non-absorbent coverings and delivered to site at a time to eliminate or reduce to a minimum, storage on site prior to fixing.
- iii. Protective coverings shall be sufficiently removed for jointing, assembly and fixing purposes and afterwards replaced.
- iv. After erection all metal work with applied finishes shall be adequately protected from any damaged and any such work which is scratched, marked or damaged in any way shall be suitably repaired if appropriate, to the Engineer's approval or, if so instructed by the Engineer, replaced at the Contractor's expense.
- v. The contractor shall submit to the Engineer evidence that the thickness of protective/decorative coatings are not less than as specified and in cases of doubt the Engineer may instruct the Contractor to send sample pieces to independent testing laboratories and the cost of all such testing shall be borne by the Contractor.
- vi. All window, door, screen, and other like frames shall be made to allow a 5 mm tolerance all round the opening in the structure and junctions shall be finished off by applying an approved sealant onto a closed cell polystyrene foam backing strip or as otherwise shown on drawings or specified.
- vii. All aluminum sections shall present clear, straight and sharply defined lines and be free from any defect or imperfection and when assembled in frames shall have an overall size tolerance of ± 1.5 mm, shall be square and with a maximum difference in the diagonal length of 3 mm.
- viii. Welding shall be undertaken in accordance with the appropriate British standard for the type of metal being joined.

- ix. Aluminum fixed against or into cementitious materials or stone/brickwork shall be adequately protected by plastic spacers/sheeting or two coats of bituminous paint applied to the fixed face of the component.

2.4 Shop Drawings

Submit complete shop drawings and calculations for all work of this section to the Consultant for approval. Do not commence fabrication until written approval has been obtained.

Shop drawings shall include, but not be limited to the following:-

- i. Plans, elevations and sections at 1:50 scale of all Curtain Wall installations.
- ii. Typical large scale unit elevations and sections at 1:20 scale, including Curtain, Wall and high level insulated panel.
- iii. Full size details of all component. members in place showing sizes, details methods of installation agreed tolerances, allowance for deflection of the structure, movement joints, junctions at walls, columns, ceilings, floors, anchorages, hardware, reinforcement, glazing, sealing and all other pertinent data to fully describe the work.
- iv. Full size details of each glazing condition showing glass, gasketry types and brand names of all materials and sizes of glass, together with drainage and ventilation of the glazing system.
- v. Details of cleaning cradle guides.
- vi. Submit structural calculations in connection with the design of all Curtain Wall and window fabrication and installation, framework, components, fixing and glass.

2.5 Samples

- i. Submit to the Consultant for approval, duplicate samples each 300 mm long of all frame sections that will be used in the External Curtain Wall, finished in the approved anodizing/powder coating color, and showing the light and dark limits. The accepted samples shall become standard for the job.
- ii. Submit sample corners of Curtain Wall units complete with glass and gaskets. Each leg of the frame to be 600 mm long properly jointed and sealed at the corner. Sample to be constructed from the approved aluminum sections. Obtain Consultant's acceptance in writing to these samples, before ordering or commencing fabrication. Approved samples shall become standard for the job.
- iii. Submit duplicate samples of all glass to Consultant for acceptance. No materials should be ordered or works commenced until samples have been accepted.
 - a. Sample of each type of glass, size 300 x 300 mm bearing name of the manufacturer and the type, thickness and quality of glass.
 - b. Samples of double glazed vision panel and spandrel panel of size 1000x 1000 mm prepared from the accepted glass sample.
- iv. Submit duplicate samples of all caulking and sealing materials and glazing gasketry in appropriate and reasonable form to Consultant for acceptance. Contractor should not order materials or begin work until Consultant's acceptance of samples has been obtained.

2.6 Manufacturer's Data

Submit to Consultant for approval duplicate copies of all manufacturer's specifications, recommendations and standard details for all work of this section covering fabrication, finishing, installation, hardware and accessories, glazing sealing, and other information required for complete description of the work.

Include certified Testing Laboratory Reports sufficient to show full compliance with the specified performance requirements.

2.7 Co-ordination

Co-ordinate work of this Section with that of other trades affecting or affected by this work and cooperate with the other trades as is necessary to assure steady progress of all work of the Contract; obtain all information from other agencies required for the satisfactory fabrication, erection and performance of the Curtain Walling system.

2.8 Guarantee

- i. The Contractor shall furnish to the Employer a written unconditional Guarantee for all work of this section, against faulty materials or workmanship for a period of ten (10) years from the date of Substantial Completion of the Project. The Guarantee shall state that any fault in workmanship or materials which may develop within the guarantee period shall be made good or replaced and reinstalled promptly, including the making good or replacement or reinstallation of adjacent work disturbed, without additional cost to the Employer.

This guarantee shall be in addition to and not in lieu of other obligations of the Contractor under the Contract.

- ii. Provide a written guarantee, signed and issued in the name of the Employer stating the sealed glazing units and other glazing units 'are guaranteed against improper fabrication, improper installation, de-lamination, discoloration or other faults for a period of ten (10) years and that any such defective units will be replaced within this period, without additional cost to the Employer.

These guarantees shall be in addition to and not in lieu of other obligations of the Contractor under Contract and other Agreements.

- iii. A technical inspector of the curtain walling manufacturer will be required to inspect the entire system and will be required to certify to the Consultant that the fabrication, erection and installation works done by the Contractor are fully in conformity with the standards, methods, specifications and codes of practice used by the manufacturer. Such certificate must be submitted by the Contractor prior to Virtual Completion of the Project.

2.9 Field Measurements

The Aluminum fabricator shall check actual window dimensions in the construction work by accurate field measurements before fabrication. Show recorded measurements on final shop drawings. Co-ordinate fabrication schedule with construction progress as directed by Contractor and if necessary, to proceed with fabrication without field measurements to avoid delay of the work, proceed, but co-ordinate and control deflection and installation tolerances to ensure proper fit of the window assemblies.

2.10 Standard

Except as otherwise indicated or specified, materials, construction and workmanship for aluminum windows of this section, the terminology, standards of performance and the design of the windows and glass shall comply with all Codes and Regulations, Local Building Regulations, Safety regulations and any other regulations applicable to the installation.

Manufacturers are to work to BS Standards or DIN Standards as appropriate. Where there is no standard in one range of standards, then the other appropriate standard shall apply:

B.S. 1474	Wrought Aluminum and Aluminum alloys for general engineering purposes -bars, extruded round tubes and sections.
B.S. 2987	Anodic Oxide coatings on wrought aluminum for external Architectural Applications
DIN 4102	Behavior in fire of building materials and components.
B.S. 961	Fixing accessories & regulations
B.S. 1331	Fixing accessories & regulations
B.S. 1769	Fixing accessories & regulations
B.S. 1494	Fixing accessories & regulations
B.S. 2874	Fixing accessories & regulations
DIN 18800	Fixing accessories & regulations

DIN 18801	Fixing accessories & regulations
DIN 18357	Fixing accessories & regulations
DIN 18360	Fixing accessories & regulations

2.11 Performance and Testing Requirements

The installation to be designed to meet or exceed the requirements of the specification as given in this section, in accordance with B.S. 6375/4315 : 1968 and DIN 18.055.

i. The installation and glass thickness are to be designed to withstand a basic wind speed of 45 m /s for the Abu Dhabi area, adjusted to a wind speed of 50 m/s with dynamic pressures of + 2180 N/m² at the 90 meter level.

ii. The window and cladding constructions are to meet the following requirements:

- a. Wind Loading: No window elements to suffer permanent distortion or other damage with deflection not greater than 1/175 negative pressures of 2180 N/m².
- b. Adequacy of fixings at positive and negative differential pressures of 2180 N/m² are to be assured.
- c. Performance when tested to B.S. 4315 : 1968 in respect of:

- **Water Penetration**

There is to be no water leakage when the window is subjected to continual steady pressure for the five minute periods at 50 N/m² (5 mm H²O increments up to a maximum of 350 N/m²) (35 mm H²O).

- **Water Penetration After Wind Gusting**

The window assembly is to be subjected to three cycles of positive and negative wind loading up to a maximum pressure of 1830 N/m² (183 mm H²O). The pressure is to be held at zero between each half cycle.

- **Air Infiltration**

There is to be no air infiltration greater than 3 m³/h per meter length of joint when the window assembly is subjected to a test pressure of 200 N/m² (20 mm H²O).

iii. Performance tests through a recognized independent testing laboratory or Agency in accordance with the specifications given above, and provide certified test results for:

- a. Water penetration
- b. Water penetration after Wind gusting
- c. Air infiltration.
- d. Deflection of window members due to positive and negative wind loading pressures.

The Contractor shall allow for all costs including the test chamber and support structure for the test units.

If any test unit fails to pass the initial testing, the Contractor shall make all necessary corrections: and have the test(s) repeated at no additional cost to the Employer.

Three copies of the Test Report shall be forwarded to the Consultant.

The Contractor shall allow for the costs for the Consultant to witness the tests.

The Contractor shall note that suitable testing laboratories are located in Europe and America. He shall allow for all costs in connection with testing to the Consultant's approval, including attendance of the Consultant if required, at testing. All the traveling and accommodation expenses, etc., shall be deemed to be included in these costs.

2.12 Sliding Windows and Doors

- i. Weather-stripping -high density acrilan or wool weather pile shall be used. There should be double brushes at every contact between shutter and frame sections for complete insulation. These should be present consistently throughout the unit between the inside and the outside and no portions without it are permitted.
- ii. The rollers for sliding shutters for both windows as well as doors shall be of adjustable type. The adjusting screws must be accessible in the assembled state of the shutters and a vertical adjustment of 75 mm should be possible.
- iii. All sections for sliding windows and doors should be hollow section and the cross section dimensions of the sections should be not less than 60 x 40mm.
- iv. The outer frame must be suitable for accommodating sliding fly screens as required.
- v. The handle-latch set should have all visible surfaces of anodized Aluminum or similar non-rusting materials to approval. The handle must have a proper grip. A small projecting flange or a recess in the shutter sections cannot be accepted to serve as handles. The latching mechanism should not be surface mounted but should be concealed within the sections.
- vi. Sash rails of vertical sliding windows are to be of tubular' box sections with corner joints of outer frames and sashes interlocked, and the balance mechanism is to be an approved proprietary product.

2.13 Side Hung Windows. Doors and Ventilators

- i. All windows and doors should be weather-stripped with heat resistant PVC sections. The weather protection should be achieved by a positive compressive action against the PVC section and should not depend on an external contact with the PVC section. At every contact between two profiles two weather-stripping sections should be provided to complete weather protection.
- ii. The bottom sections for hinged doors must be capable of being adjusted vertically if necessary. The gap between the bottom section and the floor should be covered with a pair of special splay-type PVC sections.
- iii. The shutter sections for both windows as well as doors shall be hollow section type and shall be overall size 57 x 454 mm (including flanges).
- iv. The shutters of the windows and doors should be assembled with concealed corners of high rigidity. Hinges should be concealed with the sections.
- v. Hinges shall be in anodized aluminum with stainless steel pins and nylon washers. Handles shall be in anodized aluminum and mounted with self lubricating nylon washers.
- vi. A mortice cylinder rim automatic deadlock of high quality with double pin tumbler is to be used.
- vii. Windows shall have anodized aluminum handles and a latching mechanism securing the shutter to the frame both at the top and bottom.
- viii. Fittings where required:
 - a. Single action door closer concealed in the head bar of the outer frame and mounted on an adjacent pivot at the threshold and dead lock fitted.
 - b. The left hand leaf of double doors with flush bolts at head and sill with deadlock fitted to the right hand leaf.
 - c. Escape doors to have panic bolt assembly with vertical elements concealed in the stile and door close as in (a).

2.14 Louvers

For details of louvered windows refer to windows details. Louvers will generally be aluminum. Fly screens will be fitted internally to all louvers.

3. CAT LADDERS

- i. Cat ladders where noted on the drawings shall be aluminum and unless otherwise detailed shall be constructed as follows. Stringers shall be 50 x 6 mm flat attached to the structure with 75 x 75 x 6 mm plates bolted to the structure so that the clearance of the stairs from the structure is not less than 300 mm.
- ii. Treads shall be formed of 19 mm tube riveted to the stringers.
- iii. Safety loops shall be fitted to cat ladders more than 2000 mm long and thereafter at 1000 mm intervals. The width across the loop shall be 685 mm and the distance from the centre line of the stringers to the inside of the back of the loops measured at right angles to the stringers shall be 762 mm. The loop material shall be minimum 50 x 12 mm.

FINISHES

1. SCREED

Steel wire welded mesh reinforcement shall be in accordance with BS 4485: table1, galvanized to BS 729.

Plain expanded steel lathing shall be in accordance with BS 1369.

Galvanized steel wire netting shall be in accordance with BS 1485, 19 mm mesh size.

Building paper shall be in accordance with BS 1521, class B, Grade 31F.

Polythene sheet shall be in accordance with BS 3012, 1000 gauge.

Cork joint filler will be bitumen impregnated 20 mm thick.

Compressed polystyrene board shall be in accordance with BS 3837 self-extinguishing grade, 50 mm thick to a 1.5 density.

Steel wire staples shall comply with BS 1494, part 2, galvanized and annealed iron spacing and tying wire with BS 443 1.6 mm thick galvanized.

Sand shall be to BS 1199, Table 1.

Aerated lightweight concrete mixes shall be made and laid in accordance with the manufacturer's recommendations with a minimum density of 200 kg/m³.

Bonding agent shall be of a type recommended by the cement manufacturer.

Operatives must be skilled in laying screeds.

Aerated screeds must be laid by specialist firms.

All existing work and approaches shall be protected with boards, dustsheets, or other suitable means.

During hot weather the Contractor shall ensure that full compaction is not prevented by premature stiffening or drying out of the mix. After compaction rapid drying out shall be prevented.

During wet weather freshly laid screeds shall be protected from rain.

All bases shall be thoroughly cleaned to remove all dirt, dust, rust and Oil.

Hardened in-situ concrete where screed is to be bonded:

- a. Shortly before laying screed the concrete base shall be thoroughly hacked to remove all laitance and to expose as much clean coarse aggregate as possible. All loose concrete shall be washed away and the surface left clean.
- b. 24 hours before laying screed the base shall be wetted and surplus water removed.
- c. Neat cement slurry shall be brushed on to the surface 20 minutes before laying screed, or a bonding agent shall be applied in accordance with the manufacturer's recommendations

Insulation shall be protected with building paper on all compressible slabs or quilts, paper to be lapped 50 mm at all joints.

Wire netting shall be laid over compressible slabs or quilts, lapped 25 mm at all joints and tied securely with tying wire at 300 mm centers.

On bonded concrete screed shall be laid in one course well bonded to base where screed is less than 40 mm. or laid in two courses, with lower course well bonded to base and thicker than upper courses, and neither course less than 20 mm thick. Lower course to be compacted immediately before placing upper course.

On unbounded concrete screed shall be laid in two courses without bonding to base, the lower course approximately 40 mm thick. Lower course shall be thoroughly compacted before placing upper course.

Concrete screeds shall be laid in strides not more than 3.5 wide, allowing at least 24 hours between placing adjacent strips, or in bays of not more than 30 m² in chequer-board pattern, allowing at least 24 hours between placing adjacent bays.

Square and plain joints shall be formed between screed bays or strips, closely abutted and level, and thoroughly compacted at edges.

Movement joints shall be formed in screed over movement joints in base, using jointing material placed to full depth and finished surface.

The material shall be thoroughly compacted for the full depth, without bringing any excessive laitance to the surface, removing any which does appear. The surface shall not be wetted.

Reinforcement is to be lapped a minimum of 75 mm in concrete screeds.

Tolerances for floor screeds shall be

- a. ± 15 mm overall in large open areas.
- b. ± 3 mm under a 3 Meter straight edge in areas adjacent to doors, walls and where special equipment may be installed.

No low spots shall be left between drainage outlets.

Surface of internal screeds shall be finished smooth with steel trowel or power float to receive this sheet of tiles.

Surface of roof screed shall be finished with wood or other suitable face float to give an even texture.

All defective work in screeds shall be made good before applying finishes.

Immediately after laying, the surface shall be protected from sand draughts and strong sunlight

The surface shall be covered as soon as it has sufficiently hardened either with

- a. Canvas, straw mats or a 50 mm layer of damp sand, kept damp, or
- b. Waterproof sheeting kept in close contact with the surface and shall be left for not less than 7 days in normal weather conditions.

Where different finishes are at each side of a door opening an aluminum 'T' section shall be screwed to provide a dividing strip between the different finishes.

2. GRANOLITHIC PAVING

Granolithic paving shall consist of a 1:2½ mix, one part cement to two and a half parts of granite aggregate mixed with sufficient water to give a suitable plasticity for laying. Generally the paving shall be laid immediately following the concrete sub-base. If these paving are laid on a matured concrete sub-base the concrete shall first be well roughened, wetted and brushed with a Portland cement grout.

To produce a wearing surface the granolithic mixture shall be tamped in with a wood float and trowel led twice with a steel trowel to produce a smooth finish.

The paving shall be laid in alternate bays not exceeding 9 m² in area and the bays shall be separated by division strips of brass or other approved material.

Granolithic paving shall be cured by covering with Hessian after the initial set has taken place and keeping the Hessian wet for seven days.

3. CEMENT AND SAND PAVING

Cement and sand paving shall consist of a 1:3 mix (one part of cement) to three parts of sand mixed with sufficient water to give a suitable plasticity for laying. Generally the paving shall be laid on matured concrete sub-base the same precautions should be taken as described for granolithic paving above. The paving shall be laid in bays as described above for granolithic paving.

Cement and sand paving intended as a wearing surface shall be trowel led twice with a steel trowel to produce a smooth finish. In addition two coats of sodium silicate solution shall be brushed on.

Cement - sand paving shall be cured as described above for granolithic paving.

4. CEMENT AND SAND TILES

Cement and sand tiles shall be formed with a 1:2 mix of white or colored cement, or in white cement with a color pigment added, and sand applied as a facing not less than 7.5 mm thick to a cement and sand (1:5) mix backing.

The tiles shall be cast in strong moulds under pressure to the proportions and sizes shown in the following Table.

Cement and Sand Tile Dimensions

Size mm	Size tolerance mm	Minimum total thickness mm
200x200	±0.5	20
250x250	±0.5	25
300x300	±1.0	25
400x400	±1.0	30

Colored cement and sand skirting to match tiles, 100 mm or 200 mm with chamfered top edges shall be produced in the same way as the tiles using the same mixes.

All cement and sand tiles shall be cured by totally immersing them, after the initial set has taken place, in a tank of clean water for at least 24 hours.

Cement and sand tiles shall be laid and bedded direct on to a concrete sub-floor on a cement and sand (1:4) mix screed. This screed shall be 25 mm thick in the case of 25 mm tiles and 30 mm thick in the case of 20 mm tiles. All tiles shall be laid with square joints.

All tiling shall be grouted up on completion, care being taken to fill all joints completely. The grout shall consist of neat cement of a color to match the tiling. Any surplus grout shall be cleaned off the face of the tiling and surrounding surfaces immediately and all tiling shall be carefully cleaned off.

5. TERRAZZO TILES

Terrazzo tiles shall be formed with a 1:2½ mix of white or colored cement or white cement with a color pigment added and granular marble chippings applied as a facing not less than 5 mm thick to a cement and sand (1:5) mix backing.

The tiles shall be cast in strong moulds under pressure to the proportions and sizes shown in the following Table.

Terrazzo Tiles Dimensions

Size mm	Size tolerance mm	Minimum total thickness mm
200x200	±0.5	20
250x250	±0.5	25
300x300	±1.0	25
400x400	±1.0	30

Tiles shall be cured as for cement and sand tiles and then ground, filled and polished before distribution to site.

Grinding shall be done wet by means of a No. 80 carborundum stone. Filling shall be carried out with a neat cement grout of the same color as the facing mix and this shall be worked into the surface with a wooden shaper to fill all voids and air holes. Surplus grout shall be removed with a dry cloth. After a minimum period of 24 hours polishing shall be carried out wet by means of a No. 140 carborundum stone.

Terrazzo skirting 100 mm or 200 mm high with chamfered top edge shall be **produced in the same way as for tiles using the same mixes.**

Terrazzo tiles shall be laid and bedded direct on to a concrete sub-floor on a cement and sand (1:4) mix screed. This screed shall be 25 mm thick in the case of 25 mm tiles and 30 mm thick in the case of 20 mm tiles. All tiles shall be laid with square joints.

All tiling shall be flouted up on completion, care being taken to fill all joints completely. The grout shall consist of neat cement of a color to match the tiling. Any surplus grout shall be cleaned off the face of the tiling and surrounding surfaces immediately and all tiling shall be carefully cleaned off.

All Terrazzo surfaces shall be polished on completion. Large areas such as floors shall be wet polished by means of approved machines using No. 140 carborundum wheel. Any surface too small for convenient machine polishing may be polished by hand using a No. 140 carborundum stone and water. Care must be taken during any polishing operation not to damage any angles or arises.

Terrazzo covering to items such as sills, treads and risers to steps skirting etc., shall generally be applied in accordance with the foregoing specification except that the thickness of the facing shall be at least 10 mm thick.

6. MARBLE PAVING

Marble paving shall generally be 30 mm thick and the size, type and pattern shall be as stated in the particular specification and/or shown on the drawings. The marble slabs shall be fixed solid on a bed of cement and sand (1:4) mix 30 mm thick with tight joints grouted in lime putty. A protective slurry of lime putty at least 3 mm thick shall be applied to the marble paving and subsequently cleaned off.

Treads to stairs shall be 30 mm thick fixed solid on a bed of cement and sand (1:4) mix 30 mm thick. Risers to stairs shall be 20 mm thick fixed solid on a backing of cement and sand (1:4) mix 30 mm thick. Window sills shall be 40 mm thick bedded hollow on plaster slabs. Skirting shall be 20 mm thick, in lengths of about 1.5m, fixed solid on a backing of cement and sand to coincide with joints in adjacent paving. Rounded arrises, nosings and mouldings shall be adequately protected by means of timber casing. Treads, risers, skirting and window sills shall be grouted and protected in a manner similar to paving.

The exposed faces and edges of all marble shall be polished smooth and be free from scratches or other defects. Concealed faces of marble shall be treated with shellac or bituminous paint.

7. MARBLE LININGS

Marble linings to walls, columns and the like shall generally be 20 mm thick and the size type and pattern shall be as stated in the particular specification and/or on the drawings.

The marble slabs shall be cut square and true and shall be uniform in shape and thickness. Patterns and mouldings shall be accurately formed in accordance with the drawings.

The marble slabs shall be fixed with approved proprietary non-ferrous clamps, hooks and plaster dabs leaving an air space of 12 mm behind the materials. Concealed faces of marble shall be treated with shellac or bituminous paint. The clamps shall be 25 x 5 x 100 mm girth one end and turned down and grouted into mortise in marble and the other end built into wall set 450 mm apart in each bed. Mortises shall be accurately and carefully cut and all joints shall be thoroughly grouted. The contractor is to submit details of his fixing method to the architect for approval.

Exposed edges and mouldings shall be protected by means of timber casings or lime putty coatings. The exposed edges and faces of all marble shall be polished smooth and shall be free from scratches and other defects.

Great care shall be taken to protect delivered and erected marble from chipping and staining during the course of the work. Delivered marble shall be stored in a water free area on raised platforms and shall be covered with tarpaulins or similar material unless required for use.

Erected work shall be protected at corners etc., with non-staining wood formwork, boards etc. floors shall be protected with suitable boarding, etc. after laying. Any work damaged or stained at the time of handing over shall be replaced or cleaned as required by the architect.

After completion of setting, all marble work shall be thoroughly cleaned by scrubbing with fiber brushes and mild alkaline solution that contains no caustic or harsh fillers. The use of wire brushes or acid solutions will not be permitted. Cleaning shall begin at the top of the building and proceed down wards. Upon completion, all marble shall be left clean and free from stains or traces of cleaning fluid and with all joints pointed and to the entire satisfaction of the Architect.

8. CERAMICS, GLAZED AND QUARRY TILING

Separating sheets shall either be building paper to BS 1521 Grade A1 or shall be 500 gauge polythene sheets in accordance with BS 3012.

Clay floor quarries and fittings shall be in accordance with BS 1286 type A and the thickness and size shall be as stated in the particular Specification or on the Drawings.

Ceramic floor tiles and fittings shall be in accordance with BS 1286 Type B, vitrified or fully vitrified and the thickness and size shall be as stated in the particular specification or on the Drawings.

Glazed ceramic floor tiling shall be of the type, thickness and size as stated in the particular specification or on the Drawings.

The tiles shall be true to shape, flat and free from flaws, cracks and crazing and keyed on the reverse side and shall be of a manufacture approved by the architect.

Bedding mortar shall be cement and sand all in accordance with the materials stated in Concrete work or Block work.

Any admixtures to the mortar must be approved before use.

Grout pointing shall be white or colored cement.

Cement based adhesive shall be from an approved manufacturer and shall comply with the performance requirements of CP 212:Part 1.

When bedding tiles on separating layer, tiles shall be soaked in clean water for 6 hours or until saturated, then stacked tightly together to drain with end tiles glaze outwards. Tiles shall be fixed as soon as surface water has drained.

Separating layer where required shall be laid on a level base with adjacent sheets lapped 100 mm.

Cement and sand mortar bed of not more than 20 mm or thickness of the tile shall be laid.

Tiles shall be firmly tamped into mortar to form a level surface.

The contractor shall ensure that when fixing tiles with thin bed adhesive the base to receive tiles is clean, level and dry, with no loose and friable areas and surface dusting.

Cement-based adhesive shall be prepared and used in accordance with the manufacturer's recommendations to form a bed not more than 3 mm thick.

Tiles shall be laid dry and tamped well down into the adhesive to ensure a proper bond with base and a level surface.

When bedding tiles on thick bed, semi-dry cement and sand (1:4) mortar bed shall be spread not less than 25 mm thick.

Before the compacted bed has set a cement and sand slurry (1:4) about 3 mm thick shall be spread over the surface.

The tiles shall be laid dry and tamped into the slurry to form a level surface.

Joints shall be even and not more than 3 mm wide.

Joints shall be continuous both horizontally and vertically.

The tiles shall be grouted up with white or colored cement mortar (1:1) worked well into the joints when bed is sufficiently firm to prevent disturbances of the tiles. Surplus grout shall be cleaned off from faces of tiles.

Movement joints shall be provided not less than 6 mm wide where shown.

Movement joints shall be carried through to depth of tile and bedding and partially filled with filling strip and finished flush with sealant to manufacturer's recommendations.

Where tiling abuts against wood or metal frames or other tiling at angles and around pipes, etc., it shall be carefully cut and fitted to form a close neat joint. Open irregular joints filled with cement and sand or plaster will not be permitted. Tiles shall be cleaned off and polished at completion.

Water shall not be allowed on new tiling until bedding and grouting have completely set. No traffic shall be allowed on the floor until 4 days after completion and then only light traffic for a further 10 days.

9. GLAZED CERAMIC WALL TILING

Glazed ceramic wall tiles shall be in accordance with BS 1281 with or without cushioned edges and spacer lugs.

Glazed ceramic tile fittings shall be rounded edge or angle bead type to match plain tiles.

The tiles shall be true to shape, flat and free from flaws, cracks and crazing and keyed on the reverse side and shall be of a manufacture approved by the Architect.

Bedding mortar shall be cement and sand (1:3) all in accordance with the materials stated in concrete work or Block work.

Any admixtures to the mortar must be approved before use.

Tile adhesive shall be from an approved manufacturer and comply with the performance requirements of CP 212: Part 1.

Grout pointing shall be neat white or colored cement.

The Contractor shall ensure that the cement render backing is at least 14 days old, firmly bonded to its backgrounds free from dust, with surfaces plumb and true to ± 3 mm any 1800 mm.

9.1 Fixing Tiles with Cement and Sand Mortar

The tiles shall be immersed in water for 6 hours or until saturated then stacked tightly together to drain with end tiles turned glaze outwards. Tiles shall be fixed as soon as surface water has drained. The render coat shall be wetted sufficiently to prevent it absorbing water from the bedding coat.

Mortar bedding shall be applied to render background to an even thickness of approximately 10 mm.

Each tile shall be buttered evenly with mortar and tapped firmly to position so that the bed is solid throughout.

Thickness of finished bed to be not less than 6 mm or more than 12 mm.

Any necessary adjustment to tiles shall be made within ten minutes of fixing and tiles cleaned off after not less than two hours.

9.2 Fixing Tiles With Adhesive

The tiles shall be fixed accordance with the recommendations of the adhesive manufacturer.

Adhesive shall be applied not more than 1 m² at a time, to prevent premature drying out.

Adhesive shall be applied as a continuous screed to a thickness of approximately 3 mm on the surface to be tiled.

Dry tiles shall be pressed on to the adhesive and to the adhesive and tapped firmly into position to ensure solid bedding without voids.

Any necessary adjustment to tiles shall be made immediately after bedding. Tiles shall be cleaned off as soon as bedding is complete.

Joints shall be even and not more than 2 mm wide using spacer lug tiles or spacer pegs. Joints shall be continuous both horizontally and vertically.

Tiles shall be fixed to a finished surface that is plumb and true to ± 2 mm in any 1800 mm. Joints shall be grouted up not less than 24 hours after fixing tiles to porous surfaces and not less than 3 days after fixing to impervious surfaces.

Tiles shall be grouted by pressing mix firmly into joints, working in areas of not more than 1 m².

Surplus grout shall be cleaned off as the work proceeds.

Where tiling abuts against wood or metal frames or other tiling at angles and around pipes, etc., it shall be carefully cut and fitted to form a close neat joint. Open irregular joints filled with cement and sand or plaster will not be permitted.

Tiles shall be cleaned off and polished on completion.

External tiling shall be protected from inclement weather until grouting is completely set.

No water is to be allowed on new tiling until bedding and grouting have completely set.

10. GLASS MOSAIC TILING

Glass mosaic shall be first class Italian mosaic obtained from an approved manufacturer of the colors shown in the particular specifications or on the Drawings.

The individual tiles shall be approximately 20 x 20 x 5 mm thick with an average weight of 10 kg/m²

The face of each tile shall be flat and true with opposite edges parallel. The rear edges shall be chamfered.

The tiles shall be formed of a homogeneous vitreous pasts having a high silica content and the finished tiles shall be opaque and uniform in color throughout their thickness.

The mosaic shall be fixed with soluble adhesive to a strong fixing paper in sheets 300 x 300 mm. The sheets shall be packed in stout cardboard cartons wrapped in waterproof bituminous paper. The cartons shall be contained in a strong wooden case for shipment. To facilitate handling the wooden case shall not contain more than about 3 m²

The key coat shall consist of cement and sand (1:5) mix, which should be applied four or five days before the mosaic. Application to walls etc. shall generally commence from bottom working

upwards by means of throwing the mix vigorously against the surface with a casting trowel and pressing it firmly into joints, etc., to secure adhesion. The surface should be finished plump and straight and shall be well scratched to form a key. All irregularities of the wall surface shall be leveled off and the minimum thickness at any point shall be 5 mm.

The base coat shall consist of cement and sand (1:5) mix with a proportion of imported hydrated lime of up to 20% by volume added to delay setting.

Vertical screeds shall be fixed at edges of surfaces and intermediaries as required to permit accurate application of the base coat and shall consist of timber strips 5 mm to 8mm thick x 20 mm wide. The strips shall be coated with mortar as described for base coat, firmly set to the wall and shall be carefully plumbed on face and edge. The key coat shall be well wetted and the base coat shall be applied carefully leveled between the screeds to give a smooth flat surface, which shall be kept moist until the mosaic is fixed. The screeds shall be removed and the base coat leveled up.

The bedding coat shall consist of neat white cement and water mixed as previously described for gypsum plaster. The bedding coat shall be applied immediately before the mosaic is fixed to a thickness of 1 mm. Horizontal and vertical reference lines shall be drawn on the bedding coat to ensure accurate fixing of the mosaic.

The mosaic sheets shall have their backs coated with a layer of bedding coat mortar, which shall be well troweled in over the whole sheet so that all spaces between tiles are completely filled.

The prepared sheets of mosaic shall then be fixed true to level and plumb commencing from the bottom working upwards. Each sheet shall be patted with a steel float especially along the joints between sheets. Any dropped tiles shall be replaced.

The surface shall be hammered lightly over a tapered wood block especially when the fixing paper has a dry appearance indicating insufficient projection of bedding mortar.

It is essential that the finished surface be flat and true and that the top edge be leveled.

The entire surface shall then be sprayed three or four times with water to soften the glue on the fixing paper. In case where the mosaic is exposed to sun or wind the spraying shall be substituted by brushing with a coat of grout similar to the base coat mortar. When the fixing paper is thoroughly wet, it shall be carefully peeled off keeping the hand close to the surface to prevent dislodging the tiles.

Any necessary adjustments can then be carried out to tiles to render the joints between sheets undetectable.

The surface of the mosaic shall then be sprayed with water and all traces of glue and excess mortar shall be washed off. The surfaces shall then be wiped dry with clean wood shavings. The joints shall then be grouted up using bedding mortar applied by means of a small trowel to ensure that all joints are completely filled for their full depth. Surplus mortar shall be wiped off with wood shavings. The special edge tiles ('owls-backs') shall then be applied, leveled and grouted.

The entire surface shall then be grouted once more and cleaned off with Wood shavings.

After two to six days at the discretion of the Architect the surface shall be washed with a 25% solution of Hydrochloric Acid applied by brush. The surface shall then be sprayed several times with clean water and dried off with clean white rags.

11. FLEXIBLE SHEET OR TILE FINISHES

Samples of each type of sheeting or carpet minimum size 300 x 300 mm and not less than three tiles of each type shall be provided for approval of color and pattern.

Tiles, wheat and carpets shall be delivered to the site in the original packing, each clearly marked with its batch number. All sheets, tiles or carpets of the same type, color and pattern, which will be visible together when laid, are to be from one batch to ensure consistency of appearance.

Operatives must be skilled in laying the material specified.

Work shall not be started until socket outlets, duct covers and other fixtures round which materials will have to be cut, have been fixed.

Materials shall not be laid before building is weather tight, wet trades have finished their work, and have finished their work, and the building is well dried out and all paintwork is finished and dry.

Before, during and after laying, temperature and humidity shall be main tainted at levels approximating to those, which will prevail after the building is occupied.

Where a surface to which the sheeting or tiling is being fixed is porous or dusty a primer of a type recommended by the manufacturer of the material being fixed should be used.

Where materials are to be stuck to new wet-laid screeds the contractor shall.

- a. turn off drying aids for not less than 4 days, then
- b. Test for moisture content using a hygrometer as in CP 2.3: part 2 and BRS Digest 18.
- c. Take readings in all corners, along edges, and at various points over the area being tested
- d. Not lay until all readings show 75% RH or less.

Edgings and nosing when not otherwise specified shall be:

- a. Type recommended by manufacturer of material being fixed.
- b. In the absence of such recommendations, type to be approved.
- c. Material as stated in the particular specifications.

Screw fixed stair nosing shall be bedded on adhesive.

12. PVC OR RUBBER SHEETING OR TILING

Rubber sheeting and tiles shall be in accordance with BS 1711 and the thickness and size shall be as stated in the particular specifications or on the drawings.

Anti-static rubber sheeting and tiles shall be in accordance with BS 3398 and the thickness and size shall be as stated in the particular specification or on the Drawings.

PVC sheeting and tiles shall be in accordance with BS 3261 and the thickness and size shall be as stated in the particular specification or on the Drawings. PVC sheeting or tiles may be foam, cork or felt backed as approved.

When required, anti-static PVC sheeting or tiles must fall within the range of conductivity as applied to antistatic rubber sheeting in BS 3398.

Thermoplastic tiles shall be in accordance with BS 2572 and the thickness and size shall be as stated in the particular specification or on the Drawings.

Leveling compound adhesive and polish shall be of the type recommended by the manufacturer of material being fixed or approved.

Flexible sheet underplays shall be of type recommended by the manufacturer of the finishing material, or approved.

Rolls shall be stored standing on end

Sheets and tiles shall be stored in the space where they are to be laid for at least 48 hours immediately before laying.

Plastic sheets and tiles must be stored in an air temperature of 18°C or more for at least 24 hours immediately before laying.

Adhesive shall be used in accordance with the manufacturer's recommendations. Trowel ridges and high spots caused by particles on base will not be accepted.

Materials shall not be laid if air temperature is less than minimum recommended by the manufacturers.

Pattern must match when repeating motif occurs.

Edges tiles wherever possible are to be:

- a. Equal width at opposite side of each area
- b. Not less than 75 mm wide.

Materials should be laid so that joints do not coincide with joints in base.

Joints in sheets shall be formed by overlapping sheets and cutting in to a straight edge.

Tiles shall be fixed with tight joints.

Joints in rubber and PVC sheets shall be cold welded with solvent recommended by the manufacturer.

Joints in PVC sheets shall be heat welded using welding cable.

All proud material shall be trimmed off to finish flush with adjacent surfaces.

Sheet treads to stairs shall be fixed in one piece and thoroughly rolled

Material fixed to wall shall have vertical joints.

Material shall be cut and fitted to all socket outlets, duct covers and other fixtures.

Sheets and tiles shall be cut to a straight edge on centerline of door when there is a change of material or color.

Surface adhesives must be removed from face of materials being laid and any other surfaces as the work proceeds.

Trims and edgings shall be fixed in accordance with the manufacturer's recommendations.

At least 5% spare materials suitable for patching should be retained. On completion materials selected by the Architect shall be handed over to the Employer.

Additional Requirements for Anti-Static Flooring

The screed shall be prepared and the flooring laid in accordance with the manufacturer's recommendations, using only materials supplied or recommended by him.

Contact between bonding strips and any earthed metal shall be prevented.

Electrical resistance of all anti-static flooring shall be between the following limits when measured between two separate electrodes placed 600 mm apart

- a. upper limit: average value not more than 2 meg ohms and no individual reading more than 5 meg ohms;
- b. Lower limit: average value not more than 2 meg ohms and no individual reading less than 30,000 ohms.

Electrical resistivity of completed flooring shall be tested using an insulation testing ohm-meter having an approximate open circuit voltage of 500 volts DC and capable of measuring resistance values of between 10,000 ohms and 50 meg ohms. Each electrode should weigh about 1 Kg and have a flat dry contact area of approximately 2500 Sq mm which should comprise a surface of tin or tin faced lead foil 0.012-0.25 mm thick, backed by a layer of soft rubber 6 mm thick and measuring not more than 25 international rubber hardness degrees.

The electrodes should be placed approximately 600 mm apart and the resistance measured between them. The floor surface should be wiped clean with a dry cloth before the electrodes are applied. A newly laid floor should be conditioned by regular daily washing for at least one week before measurements are taken. One test should be made for each two square meters.

The contractor shall supply an approved metal plate size 200 x 200 mm engraved with the following details, and fixed in an approved position:

- a. The works "ANTI-STATIC FLOOR"
- b. Manufacturer and reference of flooring.
- c. Name of flooring contractor.
- d. Date when laid.

All scrap shall be removed and the surfaces cleaned in accordance with the manufacturer's instructions.

Two coats of emulsion polish shall be applied to rubber surfaces in accordance with the manufacture user's recommendations.

PVC surfaces shall be dry buffed with a nylon pad to remove all marks and scratches.

No polishes, sealers or other material shall be applied to surfaces or anti-static flooring.

The floor shall be covered with clean dust sheets, hard board, etc., as necessary to prevent damage from dirt and traffic.

13. CARPETING AND CARPET TILING

Type of carpet, tiles or underlay will be as described in the particular specifications

All carpets, tiles and underlay containing paternal fibers shall be moth proofed by the manufacturer. Details of moth proofing agents and any conditions, which may be applied, shall be provided.

Tapes, which will be exposed to view in the finished work, shall be of approved color.

Tapes for binding and seaming shall be of the type and widths recommended by the manufacturer of the carpet.

Trims, fixing bars, grippers and cover strips shall be of a type recommended by the manufacturer of the material being fixed or approved.

Adhesive for floors shall be either water-resistant type or peel-up type as recommended for the purpose by the carpet manufacturer.

Adhesive for stairs, wall and seaming and jointing shall be of a type recommended by carpet manufacturer or approved.

Suitable primer shall be applied to concrete and plaster surfaces if recommended by the manufacturer of covering material or the manufacturer of adhesive.

Paper felt underlay shall be laid on all floors to be covered with foam-backed carpets not fixed by adhesive.

Hessian backed underlay shall be laid Hessian side up in whole sheet or roll sizes and pieced in only where unavoidable. Make up places shall not be less than 1 m².

In the case of lose laid carpets; the underlay shall be laid loose and trim

- a. to edge of carpet where abutting vertical surfaces
- b. 40 mm short of carpet where not abutting vertical surface.

Where carpets are edge fixed, underlay shall be fixed along perimeter of each piece to manufacturer's recommendations.

Seams of underlay must not shadow through carpet nor coincide with those of carpet when laid in same direction.

When underlay has uneven edges the seams shall be over lapped and double cut.

Rubber and rubber based underlay shall be joined with tape not less than 50 mm wide.

Underlay to stairs shall be:

- a. Out into pads to cover tread and riser and to width of stair carpet less 50 mm.
- b. Fixed to tread and riser to prevent movement and wrinkling.

Seams shall be sewn or taped as recommended by carpet manufacturer.

All seams, which are to be taped, shall be overlapped and double cut.

Thick nesses of foam-backed carpets should be adjusted with self adhesive tape as necessary to provide level surface.

Edges of loose laid carpet shall be bound with binding tape, latex adhesive or by back strapping as recommended by the carpet manufacturer.

Gripper, binder bars, trim and edgings shall be fixed in accordance with the manufacturer's recommendations.

Carpet shall be laid with seams and joints straight and parallel with one of the main areas of room.

Pattern must match when repeating motif occurs.

All lengths of carpet shall be laid with pile lying in same direction.

Carpet shall be cut and fitted to all socket outlets, duct covers and other fixtures and pieced in only where avoidable and cut in all doorways.

All edge fixed carpets shall be power stretched.

Carpet shall be fixed with gripper and neat rolled edges formed at junctions with

- a. walls, columns and other vertical surfaces
- b. Other floor finishes more than 10 mm proud of the carpet screed.

Where carpets are to be stuck adhesive shall be used in accordance with the manufacturer's recommendations. Trapped air should be removed but rollers should not be used unless specifically recommended by the carpet manufacturer.

Where carpets of different type, color and pattern are laid both sides of doorway, they shall be fixed with double binder bar or cover strip as appropriate.

Carpet shall be fixed with binder bars at free edges.

A minimum additional length of carpet shall be provided to stairs, equivalent to one tread and riser, to allow for shifting, concealed by substituting for interlay at top or bottom of stairs.

Pile of carpet must lie towards bottom of stairs.

Gripper should be fixed to bottom of all risers and to all landing and winder edges, which about a wall and exceed 300 mm long.

Carpet shall be stretched with knee kicker and fitted to each tread, riser and landing.

Carpet shall not be cut to winders, but folded under to permit sub-sequent shifting. Where carpet is to be stuck it shall be cut to match pattern.

Level of stair nosing shall be adjusted to suit thickness of carpet and underlay with continuous packing strips of hardboard, chipboard or plywood.

Carpet shall be fixed to walls with joints vertical and aligned with those on floor.

All adhesive marks shall be removed from carpet and other exposed surface as the work proceeds

The contractor is responsible for ensuring that carpet is ordered in sufficient quantity to allow for completion of the works throughout in the shades, patterns and layouts required.

In the event of the contractor under-ordering material so that there is a difference between earlier and subsequent colors and patterns in connected or related areas, the architect reserves the right to have the carpet wholly or partly removed and replaced to obtain the required effect entirely at the expense of the contractor.

All carpet is to conform to recognized international standards for use and fire spread as detailed below or in particular specification.

Tufted carpet shall be composed of manmade fibers and shall be one of the types noted in the particular conditions

- a. ASTM E-84/Flame spread ratings of 75 or less.
- b. Floor chamber test (UL 992) Flame propagation index of 4.0 or less
- c. NBS smoke density chamber test (NBS Technical Note 708) average $D_m(\text{Corr})$ of 450 or less
- d. Dimensional stability, the sum of the warp and the weft 0.45% non-recoverable extension.
- e. 50,000 revolutions on WIRA machine.
- f. Grade 5 for color fastness – light tested by Fade-ohmmeter.
- g. Grade 5 for color fastness – shampoo and wet and dry rub.
- h. Crocking – negligible.
- i. Static propensity (AATCC 134 – neolite) less than 4.0 Kv.
- j. Moth proofed.
- k. Impact – insulation Class, ASTM E 492-60 (68 over pad).
- l. Airborne – sound absorption (NRC ASTM C 423) less than 0.50.

13.1 Additional Requirements for Laying Carpets

Trims and edgings shall be fixed in accordance with the manufacturer's recommendation.

Tiles shall be laid parallel to room areas with pile of adjacent tiles and right angles. They shall be cut and fitted to all socket outlets, duct covers and other fixtures, and pieced in only where unavoidable and cut in at all doorways.

Edge tiles except where unavoidable shall be

- a. Equal width at opposite sides of each area
- b. Not less than a third of width of a full tile

Tiles shall be stuck where specified using adhesive in accordance with the manufacturer's recommendation.

All loose nap ends shall be cut away, scrap removed and carpet cleaned with broom or beater type vacuum cleaner.

Carpet shall be covered with clean dust sheets, hardboard etc., as necessary to prevent damage from dirt and traffic.

14. SUSPENDED CEILINGS

The contractor shall provide shop drawings to show the final layout and sizes of members of all suspension systems and to coordinate the design and work of suspended ceilings with other trades to provide for the reception and installation of outlets, fixtures, etc., pertaining to mechanical or electrical work, all for the Architect's approval before any work is commenced.

Workmen skilled in this work in a rigid and secure manner shall erect ceilings so that the final surface is free from any waves, buckles or sags.

15. PROTECTION

All floor & wall ceiling finishing shall be protected from damage during subsequent operations and shall be well washed or otherwise thoroughly cleaned before handing over.

PLASTERING

1. GENERAL

The Contractor shall perform all attendance upon other trades and protect all works specified under this section from damage during subsequent operations, make good any defects, clear away upon completion, clean throughout any leave all work perfect condition to the approval of the Consultant.

2. MATERIALS

2.1 Cement

Cement for plaster shall be ordinary Portland.

2.2 Sand (Fine Aggregate)

Sand (Fine Aggregate) for use in plasterwork shall be as specified for mortar under "Concrete Work" and shall contain not more than 0.6% chloride. Sand is to comply with B.S. 1198, 1199 table (1).

2.3 Water

Water shall be clean, free from any harmful matter, and free from any unusual proportions of dissolved salts.

2.4 Metal Lath

Metal lath for use plaster shall be plain expanded metal type complying to B.S 1369, weighing not less than 1 Kg/Sq.m. All metal lathing shall be zinc coated. Metal lath shall be secured to the carcass block work by means of galvanized steel nails.

Metal lath shall be provided over all junctions between concrete and block work or any two dissimilar materials where surfaces are to be plastered. The minimum overlap of the metal lath shall be 10 cms on each side of the joint. The lath shall be fixed by means of galvanized steel nails and washers at centers not exceeding 60 cms. All external and internal corners of the masonry shall be provided with plaster retaining metal angles.

2.5 Angle beads, Stop beads, etc.

All external angles to rendered finishing shall have external angle beads to ensure a true straight arris. Rendered finishing brought up to door frames, windows frames and the like shall have architrave beads and where finishing end but do not about other materials stop beads shall be used.

2.6 Color Pigments

Color pigments for tinted plaster shall conform to BS.1014.

2.7 Plaster Expansion Joint Strips

Plaster expansion joint strips where shown on the drawings or indicated in the Bill of Quantities shall be of aluminum channels maximum size 20x20mm, and 1 mm thick and shall be perforated at sides to form a suitable bond of plaster.

2.8 Curing

All manufactures of plastered areas shall be cured for a minimum of 3 days.

3. PLASTER WORKMANSHIP

3.1 Mixing of plaster ingredients

Except where and-mixing of small batches is approved by the Consultant, mechanical mixers of an approved type shall be used for the mixing of plaster.

Mechanical mixers, mixing boxes and tools shall be cleaned after mixing each batch and kept free of plaster from previous mixes. Plaster shall be thoroughly mixed with proper amount of water until uniform in color and consistency.

All plastering shall be executed in a neat workman like manner and internal and external angles shall be true, straight and plumb. Plaster shall be made good adjacent to wood or metal frames, skirting and around pipes or other fittings.

All tools, implements, vessels and surface shall at all times be kept scrupulously and strict precautions shall be taken to avoid the plasterer or other materials becoming contaminated by pieces of partially set materials which would tend to retard or accelerate the setting.

3.2 Preparation of surfaces

All surfaces to be plastered shall be clean and free from dust and grease. Projecting mortar and all traces of salts shall be thoroughly sprayed with water, but all free water shall be allowed to dry and disappear from the surface before the plaster is applied.

Plastering shall not commence until the background has been suitably prepared. Block work joints shall be deeply raked out, efflorescence brushed off and all dust and foreign matters removed. On all external surfaces and on all smooth internal surfaces spatter dash of cement and sand which shall contain 500 kgs of cement per one-meter cube of sand shall be applied and allowed to dry before rendering is commenced. All surfaces of walls shall be wetted immediately prior to applying to the first coat of rendering and this shall be allowed to thoroughly dry out before the next coat is applied.

The contractor shall form vertical guide screeds 50mm wide. The spacing shall not exceed 1.50 meters. The screeds shall be plumb and shall all be in the same plane. The sides of the screed shall be left rough to bond with plaster. The finished surface shall be true to shape and angle even in all direction, with straight rises free of cracks and trowel marks and to be entire satisfaction of the Consultant.

3.3 Proportions for internal and external plaster

Internal & external plaster shall be composed of 400 kgs cement per cubic meter of salt free sand.

Plastering shall be applied in two (2) coats unless otherwise specified or indicated on the drawings.

Finishing coat to internal plaster, which is to be limewashed, shall be composed of 200 kgs. cement and 200 kgs slaked lime per one cubic meter fine aggregate.

4. WATERPROOFING PLASTER INTERNAL SURFACES OF WATER TANKS

4.1 General

Mixing of plaster ingredients and preparation of surfaces to be plastered with waterproofing plaster shall be as specified under "Concrete works"

4.2 Workmanship

Rendering coat shall contain 450 kgs of ordinary Portland cement per cubic meter of clean coarse salt free sand and with admixture or water proofing compound added in accordance with printed instructions of the manufacturer shall be applied and the surface shall be trowel led hand and smooth and allowed to dry.

GLASS AND GLAZING

1. GENERALLY

1.1 Samples

Samples not less than 150 mm squares shall be submitted for approval for all types of glass to be used in the Works.

1.2 Storage

Glass shall be stored in a shaded and ventilated area and shall be protected from dirt and accidental damage. Care shall be taken to prevent the accumulation of water between the sheets and any glass stocks that show signs of dampness shall be separated and dried.

1.3 Indicators

Painted or stuck on indicators shall not be used on solar control or coloured glass. White wash may be used on ordinary glass but shall be restricted to small central areas of the panes.

1.4 Cleaning

All glass shall be cleaned to remove smears, excess compound and sealant on completion. Broken or damaged glass shall be replaced prior to handover of the Works.

2. MATERIALS

2.1 Glass

- i. Glass shall comply with BS 952 and shall be used in accordance with BS 6262.
- ii. Transparent glass shall be clear float or polished plate glass not less than 4 mm nominal thickness. Sheet glass shall not be used in the Works.
- iii. Wired glass shall be square pattern Georgian wired (13 mm square).
- iv. Patterned and rough cast (obscured) glass shall be to the approval of the Engineer.
- v. Solar control glass shall be body tinted, surface modified or surface coated float glass as specified elsewhere in the contract documentation and shall be of a thickness recommended by the manufacturer for the size of pane.
- vi. Hermetically sealed flat double glazing units shall comply with BS 5713.
- vii. Toughened glass shall be processed float or polished plate glass satisfying the impact requirements of BS 6202, Class B.
- viii. Glass bricks shall be hermetically sealed hollow transparent or translucent glass blocks complying with BS 952, Part 1, of the sizes, surface patterns and colours specified on the drawings.
- ix. Roof lights shall be of the types specified on the drawings, constructed in compliance with the requirements of CP 153, Parts 1, 2 and 4 and obtained from a manufacturer to be approved by the Engineer.
- x. All glass shall be of accurate size with clean, undamaged edges and surfaces which are not disfigured.
- xi. Curved glass shall be obtained from an approved manufacturer / supplier to the shape as detailed on the drawings.
- xii. Patterning of glass shall be carried out as described on the drawing by an approved specialist and shall be performed by sand blasting, grinding or acid embossing. Patterning to

mirrored glass shall be on the silvered face unless otherwise specified or approved by the Engineer.

- xiii. Pre-stressed borosilicate glass (min. 6mm) thick shall be used as a fire resistant material where detailed on the drawings.

2.2 Mirrors

- i. Mirrors shall be manufactured from float or polished plate glass minimum 6 mm thick and shall have ground and polished edges. The silvering shall be protected by a copper backing and protective paint coating.

2.3 Accessories

- i. Distance pieces, setting and location blocks shall be plasticized polyvinyl chloride complying with BS 2571 (softness number 35 to 45), rigid nylon or sealed hardwood. PVC shall not be used for heavy glass panes, solar control glasses or sealed double glazing units.
- ii. Screws for fixing mirrors shall be brass with a detachable, screw-on chrome plated brass dome to BS 1494, Part 2. Sleeves and washers shall be polyethylene.

3. WORKMANSHIP

3.1 Glazing - Generally

- i. External glazing shall be wind and watertight on completion.
- ii. All rebates and grooves shall be clean, dry, free from burrs and other projections, smooth and undistorted.
- iii. The minimum thickness of glass other than fully toughened glass shall be 6 mm when situated in the following locations:
 - a) Any hinged fully or partly glazed door and any adjacent side panel.
 - b) Any sliding fully or partly glazed door and any adjacent fixed light.
 - c) Any glass wholly or partially within a zone between floor level and 800 mm above floor level.
- iv. Glazing to internal wood doors and screens shall be bedded in self-adhesive black velvet or approved proprietary tape and secured with hardwood glazing beads fixed with brass cups and screws.
- v. Glazing to external wood doors and screens shall be bedded in approved polymer mastic performed tape and secured with hardwood glazing beads fixed with brass cups and screws.
- vi. All rebates to wood doors and screens shall be primed and sealed.
- vii. Wire glass shall be fixed with the wires parallel to the surround and aligned in adjacent panels in single and double doors.
- viii. Fire resistant glazing channel shall be butt jointed at corners and fixed with 38 mm countersunk brass screws at not more than 200 mm centres and not more than 50 mm from each end. The butt joints of glazing channels for one hour fire resisting doors shall be sealed with intumescent mastic.

3.2 Glazing Aluminum Windows Externally

- i. Generally the glazing system shall utilize snap-in beads and neoprene glazing gaskets. Other glazing techniques involving the use of glazing compounds, sealants etc., shall be submitted to the Engineer for approval together with details of similar installations successfully employed elsewhere in the Gulf region.
- ii. Unless otherwise indicated elsewhere in the contract documentation the maximum permitted size of an external glass pane with all four edges fully supported in a low rise building

(maximum 10 metres high) shall not exceed the areas given in Table 4.2.

- iii. The recommendations of the glass manufacturer shall apply in all situations not covered by Table 4.2 and where the information is not provided in the contract documentation. The recommendations shall be based on a 3 second gust exceeding 46 metres/second at 10 metres above ground level occurring in UAE. on average only one in 50 years and a ground roughness category of 1.
- iv. The depth of rebates for bead glazing shall not be less than that shown in Table 4.3 and the minimum edge clearance (distance between the edge of the glass and the surround) shall not be less than 3 mm for any glass up to and including 12 mm nominal thickness. The recommendations of the glass manufacturer shall apply for all glass over nominal thickness.
- v. The minimum edge cover to single glazing shall be as Table 4.04 and equal all round each pane. The edge cover and clearance to double glazing units shall be as recommended by the manufacturer of the units.
- vi. Setting blocks shall be used between the bottom edge of the glass and the frame or surround, to support and centralize the glass in the opening. The minimum length of each block shall be equal to 30 mm per square metre of glass area and the width shall be equal to the thickness of the glass (or glass insulating unit) plus the back clearance.
- vii. Location blocks, shall be used in opening windows and doors between the edges of the glass, other than the bottom edge, to prevent movement when they are opened. Each block shall be at least 25 mm long and the width shall be equal to the thickness of the glass (or glass insulating unit) plus the back clearance.
- viii. Setting and location blocks shall be positioned as near to the quarter points of each side as possible.
- ix. The glazing gaskets shall be positioned on both sides of the glass and shall be correctly sized so that when forced into the space between the glass and surround sufficient pressure is provided to support the glass structurally and to form an effective seal against the weather. Care shall be taken to ensure that the gasket is correctly located in the grooves and the glass is completely bedded.

3.3 Fixing Mirrors

Mirrors shall be fixed with spacer washers to compensate for irregularities in the wall surface and with sleeves and washers to prevent contact between the mirror and the fixings.

4. STANDARDS AND TABLES

4.1 Standards

The standards referred to in this Section are:

BS 952	Glass for glazing
BS 1494	Fixing accessories for building purposes
BS 2571	Flexible PVC compounds
BS 5713	Hermetically sealed flat double glazing units
BS 6206	Impact performance requirements for safety glass and safety plastics for use in buildings
BS 6262	Code of Practice for glazing for buildings

4.2 Maximum Areas for Glass Panes Situated Externally

TYPES OF GLASS

				NOMINAL THICKNESS IN mm					
				4	5	6	7	10	12
				m2	m2	m2	m2	m2	m2
Transparent	Float	or	Polished	1.30	2.00	3.00	4.00	5.50	8.00
Plate				-	-	1.25	-	-	-

Wired cast	-	-	1.80	-	-	-
Wired polished	0.70	1.20	1.75	-	-	-
Rough cast and pattered	1.80	2.90	4.20	-	1.00	-
Fully toughened	-	-	2.80	4.00	5.50	-
Transparent laminated						

NOTES:

1. The table is based on a 3-second mean wind loading of 1600N/m²
2. The table does not apply where the building exceeds 10 metres high or where the length/breadth ratio of pane is greater than 3:1 and is therefore considered as two-edge supported.

4.3 Minimum Rebate Depths for Bead Glazing

NOMINAL GLASS THICKNESS	MINIMUM REBATE DEPTH
mm	mm
4	10
5	12
6	12
10	15
12	15

ROOFING AND INSULATION

1. GENERAL

The Contractor shall provide all the materials, labor and equipment, etc. for this work and shall carry out and complete the entire work of roof finishes as per specifications detailed as below.

The work of finishes shall consist of the following:-

- a. The bitumen primer coat to concrete roof slab.
- b. Thermal insulation / Foam concrete
- c. Sheathing membrane
- d. Sand / cement screed.
- e. Roof waterproofing and U/V protection.
- f. Cement Roof Tiles.
- g. Flushing membrane, corner strip.

2. GUARANTEE

The Contractor shall submit to the Client a guarantee in the form of Bank Guarantee for the specified number of years as mentioned in this tender for the roof finishes & water proofing from any of the approved Local Banks prior to initial takeover of the project by the Client. A specimen copy of the Waterproofing Guarantee is provided in the tender document.

The Bank Guarantee must cover the cost of labor, plant and materials for replacement and repair of the roof finishes, waterproofing and insulation in the event of its failure or leakage during the course of the number of years as mentioned in the conditions of this tender from the date of the initial handing over of the project.

3. TESTING

The Contractor is to test to the satisfaction of the Engineer all areas of the roofing and waterproofing for water penetration. These tests are to be carried out after the membrane has been laid. The Contractor is to allow in his rates for such areas to be flooded with water and left for a minimum of 48 hours.

On completion of the roofing works the Contractor is to leave the roof in a sound and watertight condition, to the satisfaction of the Engineer.

4. SPECIFICATIONS

4.1 Insulation

4.1.1 Polystyrene Rigid Foam Boards

Contractor shall lay a layer of 5 cm thick polystyrene boards fully bonded to primed surface of the screed or directly on the concrete slabs as specified there under. Bonding shall be done either by hot bitumen or any other approved bonding agent recommended by manufacturer. Above polystyrene rigid boards shall comply with the following:-

Thickness	5 cm
Thermal conductivity at 10°C Mean temperature	$k = 0.028 \text{ W/m deg C}$
Density	32.35 kg/m ³
Water absorption	0.1% volume
Capillary	None
Compressive strength at 5% Compression	0.245 M/N/m ²

There shall be no air between screed or concrete slab and polystyrene board.

4.1.2 Foam Concrete

The foam concrete (Lightweight concrete) should have the following specification:

- a) One cubic meter of mix components are:

300 kg Ordinary Portland cement
4 Liters foaming agent (Aistexsa foamer)
240 Liters clean water

- b) Clean water is added to mixer while stirring is in progress cement is added, then foaming agent the foam concrete is then easily pumped onto the roof deck and extended.
- c) 48 hours should elapse before roofing material and applied –in case of rain, allow an additional 24 -hours period.
- d) Wet density : 500-550 kg/m³
Dry density : 350-400 kg/m³
Chemical resistance : excellent
Compression strength : 4-6 kg/cm²
Thermal conductivity : 0.079
Average thickness : 70 mm (50-100 mm) in slope

4.2 Sand / Cement screed

- a) Minimum 3 cm thick sand cement screed layer -1 part cement to 4 parts clear sand -shall be laid to falls and cross falls 1 % or as specified on the drawings, over the concrete roof slab or the roof thermal insulation depending on the types of roof finishes specified hereunder. Maximum thickness of the screed shall be 10 cm.
- b) Sand used for the screed shall comply with BS 882 and be clean natural sand, free all salts and other impurities, graded passing through a 4.75 mm British Standard sieve a good proportion of larger particles.
- c) Cement shall be Portland cement complying with BS 12: 1978 for ordinary and rapid hardening Portland cement. Water shall comply with BS 3148.

4.3 Waterproofing

- a) The coating impregnating mixture of the water proofing membrane, (which is the waterproofing agent of the same) consists of bitumen heavily modified with thermoplastic resins stabilizers and anti-oxidizers. The membrane shall have 4 mm thickness. The membrane shall have an excellent resistance to the atmospheric agents, to aging, shape stability at high temperature, high adhesion strength. The membrane shall be reinforced with a haze of polyester, woven non woven, at continuous thread and to have a weight of 250 gm/m².

The membrane rolls are unrolled and placed in the correct position to be torched on later. During this stage each roll must overlap the next one by min. 10 cm. The membrane rolls are re-rolled again and its surface slightly heated (Transverse movement) by means of gas torch, to cause surface melting and subsequent adhesion to the surface.

- b) As above but with aluminum paint on top for ultraviolet protection or with mineralized or aggregate top.

4.4 Priming of concrete roof slab surfaces

The surfaces of roof slab shall be thoroughly cleaned, primed and given two coats of oxidized bitumen 115/15 at the rate 2 kg/m² brush applied to cover all the surfaces -up stands, sleeves of ducts, pipes, etc. that are required to be covered with roof finishes mentioned above.

4.5 Sheathing membrane

Polythene "Visqueen" 500 grade or similar member laid with necessary side laps (10 cm) and end Laps as required (Min. 15 cm).

4.6 Cement paving tiles

Shall be hydraulically pressed, square edges sizes 40 x 40 x 3 cm thick made from Portland cement and aggregates -all to comply with BS 368 -1971.

4.7 Mastic sealant

Mastic used for the joints shall be cold poured -2 part polysulphide based sealant confirming to BS 4254, 1967.

5. UP-STAND JOINTS

At all up-stands as shown in the drawings the Contractor shall turn up the waterproof membrane over a timber tilting fillet, size 50 x 50 mm. The skirting shall be fixed to the vertical element tucked into a performed groove and sealed with mastic sealant.

Contractor must use the appropriate type of detail for horizontal and vertical joints as shown on the drawings. Up-stands for expansion joints on the roof shall be properly covered with the waterproofing membrane over the plastered vertical and horizontal surfaces. Joints shall be properly sealed with approved mastic sealant and protected from damage by providing pressed aluminum sheet cover as indicated in details on the drawings.

6. MISCELLANEOUS MATERIALS

6.1 Primer

The primer to be used shall comply in all respects with ASTM D41 and shall be applied at a minimum rate of 250-300 g /S .m per coat.

6.2 Cold adhesive

The cold applied roofing adhesive to be used shall comply with A S T M D 3018 type III and shall be guaranteed by the manufacturer for this specific application. It shall be applied at a minimum rate of 500g/Sq.m: i.e. 5 spots/Sq.m.

6.3 Separate layer

Non woven synthetic geotextille of 100 or 140 g/ Sq. m. (with 10% tolerance)

6.4 Metal flashing

1.5 mm minimum thick aluminum sheet, colour at the Consultant's request.

6.5 Mastic Sealant

Polysulphade, silicone or polyurethane rubber sealant

6.6 Nails

Shall be aluminum nails, complying in all respects with BS 1202

7. STORAGE MATERIALS

- 1) All materials shall be stored in dry area out of direct sunlight.
- 2) It is not permitted to store material on the building in such concentrations as to impose excessive stress and strain on deck or structural members.

8. EXECUTION

8.1 Inspection –preparation

The Contractor is required to ensure the following:

- a) All surfaces to be roofed and waterproofing shall be properly prepared by brushing, cleaning and leaving the surfaces free from dirt, dust, grease, loose or projecting particles of mortar or concrete.

All traces of salt shall be thoroughly sprayed with water and allowed to dry and disappear from the surfaces before the application of the waterproofing system.

- b) The roofing system shall be laid to drain water freely into the rain water outlet).
- c) All items to be installed on the roof which require penetrations through the roof membrane and placed prior to the application of the membrane.
- d) Fill voids and cracks in substrate, including walls as recommended by the membrane manufacturer.

8.2 Installation –general

Install materials in accordance with manufacturer's printed instruction Manufacturer's technical representative shall remain present as necessary to ensure installation

8.3 Installation -membrane and flashing

8.3.1 Membrane

Install membrane in strict compliance with manufacturer's instruction. One of the following laying methods are used worldwide to install a waterproofing membrane over its substrate

- Fully bonded system: The membrane is 100% adhered.
- Partially bonded system: Adhesion by "spots" only usually 15% of surface.
- Loose laid system: Membrane is not adhered at all

Using any of these methods shall be according to the type of waterproofing system being applied as shown in annex I and II.

8.3.2 Installation of the Insulation

The contractor is required to:

- 1- Place 50 mm thick insulation where required in the waterproofing system, tightly bull boards and staggering joints.
- 2- Cutting the insulation to shape and maintain 15 mm clearance from projections in inverted roof system
- 3- Bonding in the insulation to deck with cold adhesive in conventional system.

8.3.3 Insulation of the Ballast

The Contractor is required to:

- 1- Place 50 mm thick ballast (washed, rounded natural gravel 15/25 mm) with a minimum uniform rate of 73 kg/Sq.m covering all the roof area as per drawing.
- 2- This layer will be laid on a 140 g/Sq.m separation layer with a minimum 150 mm lapping.

8.3.4 Installation of the Flashing Membrane

Installation of a flashing membrane will be in strict compliance with manufacturer's instruction.

The roofs shall receive a flashing membrane consisting of the following build up:

- 1- One coat of bitumen primer to ASTM D 41
- 2- Laying of the flat area roofing system.
- 3- 20 cm reinforcing strip, fully torched on the angle, 10 cm horizontally + 10 cm vertically.

- 4- Laying flashing membrane fully torched 20cm horizontally + vertically to the required height.
- 5- Flash membrane into drain and items such as pipes and other items passing through membrane.

Note: All joints must be sealed water and air tight, free from fish mouths and other defects.

8.3.5 Insulation of expansion joints.

- 1- The waterproofing system shall be laid in strict conformity with manufacturer's instructions.
- 2- All surfaces to be waterproofed shall be properly prepared by brushing, cleaning and leaving the surfaces free from dirt; dust, grease, loose or projecting particles of mortar of concrete. All traces of slat shall be thoroughly sprayed with water and allowed to dry and disappear from the surfaces before the application of the priming coat.
- 3- The width of the joint to be waterproofed shall be minimum 2 cm and a 3x3 cm chamfer is to be foreseen in the concrete edges.
- 4- Then the concrete deck is primed 15-20 cm on each side of the joint, chamfered edges of the joint shall not be primed.
- 5- A 15-20 cm wide base strip 4 mm glass reinforced bituminous membrane is torched on each side of the joint.
- 6- A 5 mm thick un-reinforced SBS membrane is torched 10-12 mm on one edge of the joint, formed in a U shape into the chamfered edge (A shovel stick is the ideal tool) and then torched 10-12 cm on the other edge, being kept loosely laid onto the chamfered edges.
- 7- To prevent water stagnation and dirt, the place must be filled with a self extinguishing expanded butyl foam baking rod.
- 8- At the final stage, the expansion joint must be protected by a 4 mm reinforce membrane with granules or metal face as required.

8.3.6 Insulation of roof outlets

- 1- All drain outlets shall be located at the lowest part of the roofs.
- 2- All drain outlets to be connected to a roofing system shall be fitted with a built-in horizontal flange allowing for at least 100 mm overlap with the membrane in all directions.
- 3- All flanges shall be located at RC slab level.
- 4- Whenever PVC drain outlet specified the membrane must not be torched over the PVC flange. A metal sheet, ductile, non corroding, at least 0.6 mm thick, shall be laid over the PVC (self adhesive metal sheet or glued with compatible approved adhesive) and then shall be primed to receive the membrane)

9. TILES EXPANSION JOINT

Through tiles and mortar, provision for a 2 cm wide expansion joint to be filled with mastic shall be made at root- perimeter and every 3 meters in both directions. Mastic shall be 20x20 mm laid onto approved baker rod.

PAINTING AND DECORATION

1. GENERAL

All painting and decorating materials shall be supplied in accordance with the manufacturer's printed instructions.

Every possible precaution shall be taken to keep down dust before and during painting processes. No paint shall be applied to surface structurally or superficially damp and all surfaces must be ascertained to be free from condensation, efflorescence, etc., before the application of each coat.

Primer or undercoated woodwork and metalwork should not be left in an exposed or unsuitable situation for an undue period before completing the painting process. No exterior or exposed painting shall be carried out under adverse weather conditions, such as rain, extreme humidity, dust storm, etc.

Metal fittings such as ironmongery etc. not required to be painted shall first be fitted and then preparatory processes are commenced. When all painting is completed the fittings shall be cleaned and re-fixed in position.

The contractor will be required to repaint, at his own expense, any work where the paint is incorrectly applied. The contractor shall be responsible for protecting from damage the paintwork and all other work during and after painting operations including the provision of all necessary dust sheets, covers, etc.

Brushes, pails, bottles, etc., used in carrying out the work shall be clean and free from foreign matter. They shall be throughout cleaned before being used for different types or classes of material.

The number of coats stated in this specification is the minimum, and the contractor must apply sufficient coats to achieve a proper even finish to the approval of the architect.

2. MATERIALS

The decorating material shall be obtained from approved manufacturers and shall be supplied in the manufacturer's sealed and branded containers.

All materials must be thoroughly stirred before use, unless not recommended by the manufacturer.

Details of mixing and application shall be in accordance with the specifications of the manufacturers concerned and to the approval of the Architect.

The mixing of paints, 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.

Mordant solution shall be of approved manufacture.

Rust inhibitors shall be of approved manufacture.

Stopping for woodwork to receive clear finish shall be tinted to match surrounding woodwork, to approval.

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

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

Thinners shall be approved turpentine or white spirit to BS 245

Priming paints shall be:

- a. for woodwork: leadless grey priming paint in accordance with the recommendations of the decorative coating manufacturer;

- b. for steel work: red oxide priming paint in accordance with BS 2524
- c. for galvanized, zinc or aluminum alloy surfaces: grey zinc chromate priming paint in accordance with BS 3698
- d. for plaster: concrete and block work, ceiling boards, etc., alkali resisting priming paint in accordance with the recommendations of decoration ceiling manufacturer.

Knotting shall be in accordance with BS 1336.

Undercoating shall be:

- a. zinc oxide based undercoating paint;
- b. White lead based undercoating paint in accordance with BS 2525-7. Colors shall approximate to the finishing paint;
- c. Synthetic alkyd based undercoating in accordance with the recommendations of the decorative coating manufacturer.

Finishing paint shall be as shown on the drawings with the minimum specifications:

- a. zinc oxide based oil paint;
- b. White lead based oil gloss finishing paint in accordance with BS 2525-7. Colors shall approximate to the finishing paint;
- c. Synthetic alkyd based finishing paint as approved by the Architect.

Petrifying liquid shall be used undiluted as supplied by the manufacturer. A small quantity of water paint of the finishing color may be mixed with the petrifying liquid.

Water paint shall be an approved brand of washable oil bound water paint complying with BS 1053 type A. Thinning shall be done with petrifying liquid or fresh water only.

Emulsion paint shall be of the Polyvinyl Acetate (PVA) type obtained from an approved manufacturer. The precise specification shall comply with the manufacturer's normal practice. In all cases thinning shall be done with thinners supplied by the manufacturer or fresh water only.

Stain for woodwork shall be an approved brand of oil stain complying with BS 1215.

Polyurethane lacquer for woodwork shall be of an approved manufacture.

3. PREPARATION PROCESS

Internal Plaster, Fair Faced Concrete and Block Work

Surfaces shall be allowed to dry out completely and cracks shall be cut out and make good with suitable hard plaster or cement and sand mix as appropriate, such repaired portions shall be allowed to dry out. No painting shall be carried out on plastering less than five weeks old.

Efflorescent 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 from of decoration.

Surfaces, which are to receive water paint, shall be treated with one coat of petrifying liquid applied by brush and allowed to dry for at least 24 hours before the application of water paint. A period of 24 hours or longer if necessary shall be allowed between subsequent coats.

Fair-faced concrete and/or cement and sand plastered surfaces, which are to receive oil paint, shall be given one day. 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 priming coat of oil paint.

All surfaces, which are to receive oil paint, shall be treated with one coat of alkali resisting priming paint applied by brush and allowed to harden completely.

4. FIBER BOARD, ETC.

Soft board: where used eternally or under humid conditions will receive ore coat of priming paint and one coat of undercoat on back, face and edges.

Soft board: where used internally will receive one coat of priming paint and one coat of emulsion paint on back, face and edges.

Hard board: composite panels will be treated in the same way as soft boards under humid conditions.

Acoustic board: will be treated on the face in the same way as plaster, but the paint may be applied by spray; the backs and edges should not be treated.

5. STEELWORK INCLUDING WINDOWS, LOUVERS, ETC, INTERNALLY & EXTERNALLY

If delivered galvanized, the surface shall be cleared to remove grease and dirt before priming. Where rusting has occurred through damage to the galvanizing such rust shall be removed by wire brushing back to clean metal and the surface shall then be treated with one coat of mordent solution and one coat of zinc chromate priming paint.

If delivered primed, the surfaces shall be examined to ascertain that the priming paint is hard, firmly adhering and in good condition. If not satisfactory, the priming paint shall be removed and the surfaces cleaned to remove rusts and re-primed. If the condition of the priming paint is satisfactory, the surfaces shall be cleaned to remove grease and dirt, minor damage to the priming paint, being made good with red oxide priming paint after removal of rust.

If delivered unprimed and not galvanized, the surfaces shall be clean remove grease and dirt, and wire brushed and scraped to remove all rust and scale before applying a red oxide priming paint.

Priming paint shall be brushed well into the surface and shall be allowed to dry and harden thoroughly before the application of subsequent coats.

Items of steel work such as frames to roller shutters, covers to expansion joints, etc., which are to be built into walls, shall first be primed.

The Architect reserve the right to have rusted items removed from the site and reloaded at the contractor's expense if he considers the item has been too badly affected or incorporation in the works.

6. EXPOSED SERVICE PIPES

Copper and brass pipe work shall have the surface slightly abraded with glass paper and white sprite or similar solvent and wiped cleared. No priming paint will be necessary, the surface being finished in two coats of gloss paint.

Steel pipes will be treated as for steel work with exception that galvanized pipes are to be treated with a zinc chromate priming paint.

Coated soil pipes shall be wiped clean and treated with two coats of knotting followed by priming paint as described earlier.

7. WOODWORK REQUIRED TO BE PAINTED

Surfaces shall be cleaned to remove grease and dirt. The surface of teak shall be cleaned with white spirit to remove free oil. The preparation process shall then be:

Knot: All knots shall be treated with shellac knotting;

Prime: One coat of primer shall be thoroughly applied by brush to all surface and when dry a further coat to be applied to end grain surfaces;

Stop: When priming paint is hard all cracks, hole, open joints, etc., shall be make putty or an approved filler and rubbed down with, fine glass paper.

No joinery shall be primed until the Architect has approved it. Priming shall be carried out on the site and not in contractor's workshop.

Items of carpentry work, which are to be built into walls, etc., shall be first treated by twice coating with creosote or other approved preservative.

8. WOODWORK REQUIRED TO BE STAINED

Surface shall be cleaned to remove crease and dirt. The wood shall be stopped, filled and rubbed down. In case of teak, free oil shall be removed by cleaning with white spirit.

9. FINISHING PROCESSES

Where emulsion paint is specified at least three coats shall be applied by brush in addition to any priming paint in order to produce a finish to the Architect's satisfaction.

Where water paint is specified two coats shall be applied by brush in addition to the petrifying liquid. The water shall be thinned to the consistency of thick cream.

Where oil paint is specified this shall be two or three coat work as detailed in the manufacturer's specifications, applied by roller or brush, but not by spray, to produce hard gloss, oil gloss, eggshell or flat finish as required.

The finishing coat of paint to walls and ceiling shall be applied after the completion and testing of the electrical installation. Any paint splashes on electrical fittings shall be carefully cleaned off.

10. WOODWORK REQUIRED TO BE STAINED AND POLYURETHANED

The woodwork, internally and externally shall be stained as directed on site, rubbed down, brushed off, and treated with at least two coats of polyurethane to the satisfaction of the Engineer.

11. PROTECTION OF FACTORY FINISHED WORK

The contractor is to allow for protecting all factory finished doors, frames, windows, suspended ceiling and the like at all times to ensure that factory finishes are not damaged and must make good or replace any defective component at his own expense.

The contractor must also remove, store and replace ironmongery, electrical faceplates, light fittings and the like as necessary to protect them from surrounding.

CARPENTRY & JOINERY

1. CARPENTRY

1.1 Timber Generally

- i. All timber shall be clean, sound, of merchantable quality, properly seasoned and free from woolly texture, soft heart, sapwood, splits, shakes, wavy edges, fungal and insect attack, faults caused by compression failure and any defect or combination of defects, natural or otherwise.
- ii. Sizes of timber shall be in accordance with BS 5450 (for Hardwood) BS 4471 (for Softwood).
- iii. Unless specifically stated otherwise, sizes shown on drawings are finished sizes and the Contractor must allow within his costs of forming wrot faces from appropriate larger sizes.
- iv. Where unwrot sizes are shown on drawings reductions to finished sizes shall not exceed that permitted by BS 5450. Finished timber sizes shall be approved by the Engineer before the wrot piece is fixed.

1.2 Moisture Content

- i. All timbers (softwood and hardwood) shall be kiln dried to a moisture content of 11.0% - 13% (12% average) before transportation.
- ii. Each batch shipped shall have accompanying documentation verifying this and any batch without such documentation will be rejected.

1.3 Preservatives

- i. When stated on the drawings/schedules treated timber shall mean timber treated with copper chrome arsenate (CCA) fixed water-borne preservatives applied by vacuum pressure impregnation in accordance with BS 4072.
- ii. All softwood shall be treated as in Clause 7.1.3(i) whether or not stated on drawings/schedules.
- iii. The Engineer shall be informed of the firm undertaking the timber treatment and the Contractor shall obtain from the firm a certificate of treatment for every consignment of timber treated, which shall be re-submitted to the Engineer.
- iv. Treatment shall be carried out after machining of timber except that brush or spray application of the manufacturer's preservative, in two application to any cutting or boring subsequent to the initial treatment, will be carried out to the Engineer's approval.
- v. All water borne preservative treatment shall be undertaken in good time for timber to dry out before allowing the treated timber to contact any other materials or components.

1.4 Hardwood

- i. All Hardwood shall be in accordance with the requirement of BS 1186:Part 1 and BS 4047 and shall be of first quality, sorted and selected at time of fabrication of suitability of purpose and to give a harmonious appearance to the approval of the Engineer.
- ii. The species of hardwood shall be as indicated on the drawings/schedules.
- iii. In addition to the requirement of Clause 1.1(i) all hardwood shall show a straight and regular grain throughout, shall have a consistent colour in all locations and be free from knots on exposed faces.
- iv. Any hardwood showing visible imperfections will be rejected.

1.5 Softwood

- i. All softwood shall comply with the requirements of BS 1186 Part 1.
- ii. In addition to the requirements of Clause 1.1(i) all softwood shall be free from pith showing on the surface, sloping grain exceeding 1 in 8, checks and shakes, knots exceeding 25mm diameter, arris and splay knots, decayed or loose knots and knots holes.

- iii. Softwood shall be one of the following:

Species (BS 881, 589:1974)	Origin
Whitewood / Europe spruce (Picea abies)	Europe
Scots pine / Redwood (Pinus sylvestris)	Europe
Douglas fir British Columbian pine (Pseudotsuga taxifolia)	Canada / USA

1.6 Plywood

- i. All plywood shall comply with the requirements of BS 6566 Grade II and B on both faces and shall be of Canadian or Finnish origin obtained from a manufacturer to be approved by the Engineer.
- ii. Except where stated otherwise plywood shall be Exterior Grade WBP Bonding with synthetic resin adhesives to BS 1203.
- iii. Plywood shall be supplied by the manufacturer in the thickness as stated on the drawings/schedules.
- iv. Plywood shall be manufactured from hardwood and shall be free from end joints, (including joints in veneers) overlaps in core veneers, dead knots, patches and plugs, open defects, depressions due to defects in cure, insect attack (except isolated pinwork holes through face veneers only), fungal attack and from discoloration differing from that normally associated with species of timber used.
- v. Face veneers shall be hard and durable and shall be capable of being finished to a smooth surface to receive coatings.
- vi. Marine plywood shall be to BS 1088 and 4079 and of balanced construction.

1.7 Mechanical Fastenings and Fixings

- i. Non-standard metal work used in cleats, brackets, straps etc. and standard sections as detailed in the drawings shall be from mild steel in accordance with Section 9, Metalwork.
- ii. All fastenings described below shall be of steel unless otherwise stated.
- iii. All ferrous metalwork, nails, screws, bolts and other mechanical fastenings shall be protected by galvanizing after manufacture in accordance with Section J10, Metalwork or, where appropriate the relevant British Standard for the item.
- iv. Nails shall be high grip nails with annular ringed or helical threaded shank to BS1202: Part1.
- v. Screws shall be to BS 1210 or BS 1494
- vi. Plain hexagon bolts shall be to BS 1490.
- vii. Washers large diameter, shall be to BS 4320.
- viii. Expanding bolts shall be proprietary devices comprising corrosion resistant expanding insert

and removable bolt or threaded stud to suit the work being fixed, of a pattern and make to the approval of the Engineer.

- ix. Frame cramps shall be of an approved pattern and material and shaped for building in.
- x. Timber connectors, where indicated on the drawings, shall be of the toothed plate type to BS 1579.
- xi. All mechanical fastenings and fittings shall be adequately protected from corrosion and all exposed bolts are to be capped with an approved dome headed nut.

1.8 Adhesives

- i. Adhesives shall comply in all respects with BS 1204 and BS 5442 Part 3 and shall be used in strict accordance with the manufacturer's printed instructions.
- ii. For joints in non-load bearing internal work and for joints in work where the moisture content is always less than 16 per cent organic or casein glues may be used.
- iii. For work under damp conditions (moisture content normally 20 per cent or more or conditions liable to fungal attack) resin type adhesives shall be used.

1.9 Packing, Delivery and Storage

- i. All timber must be polythene wrapped at 12% moisture content prior to transportation.
- ii. Protection shall be such as to protect the timber against stain, discoloration and other surface injuries during transportation and erection on site. Protection shall be of such composition that it may be easily removed when work is complete, without being harmful to the surface of the timber.
- iii. The polythene shall be removed as soon as possible and the timber close stacked in the shade, clear of the ground on leveled bearers in a manner that prevents sagging and permits free air circulation.
- iv. When stored externally timber shall be covered during wet weather and uncovered during dry weather.
- v. Temporary covers should be kept from close contact with the timber.
- vi. Unless otherwise approved by the Engineer, joinery that shall be finally fixed in an air-conditioned environment shall be stored, immediately prior to fixing, in similar conditions to those designed for that location and for a period sufficient to enable to acclimatization to that environment.

1.10 Workmanship

- i. Timber shall be sorted and selected at time of fabrication for suitability for purpose and its function in the Works.
- ii. The moisture content of timber shall be checked, before fixing, with a reliable, properly calibrated meter and timber with moisture content in excess of 2% above that specified shall not be fixed.
- iii. Timber shall be sawn truly square, straight and free from burrs.
- iv. Joints shall be as shown on the drawings but where not specifically shown shall be the recognized form of joint with regard to its location and such that they tighten under load, resist tension as appropriate to their function and are without gaps or imperfections.
- v. Loose joints shall be used where provision must be made for shrinkage or other movements acting other than in the direction of the stresses of fixing or loading.
- vi. All joints, arrises, recesses, etc shall be plumb, true and square.

- vii. All units and members shall be installed such that they are truly plumb or horizontal.
- viii. The carpenter shall perform all necessary mortising, tenoning, grooving, matching, tonguing, housing, regating and all other works necessary for correct jointing.
- ix. All metal plates, screws and other fixings that may be required or necessary for the proper execution of the carpentry works shall be provided.
- x. The carpenter shall also carry out all works necessary for the proper construction of all framings, linings, etc., and for their support and fixing in the building.
- xi. Nails, sprigs, etc shall be punched and puttied.
- xii. Screw heads in work to be painted shall be countersunk and stopped.
- xiii. Glued joints shall be used where provision need not be made for shrinkage or other movements in the connections and where sealed joints are required.
- xiv. Glued joints shall be cross-tongued or otherwise reinforced so as not to be wholly dependent upon the adhesive.
- xv. Surfaces to be glued shall be clean, free from dirt, dust, sawdust, oil and other contaminants and shall have a good sawn or planed finish.
- xvi. Adequate pressure shall be applied to glued joints to ensure intimate contact and shall be maintained whilst the glue is setting.
- xvii. Unless specific sizes are stated on the drawings/schedules screws shall be of a size and length to suit pre-drilled holes in metal work and the dimensions of the timber being fixed.
- xviii. Screws shall be fully driven home and timber shall be pre-drilled where necessary.
- xix. Screws fixed into masonry, concrete and block work shall be plugged using approved durable proprietary fibre composition or plastic plugs of suitable size and length for the fixing and at centres necessary to provide adequate support but not exceeding 600 mm.
- xx. Masonry nails shall not be used for fixing timber to masonry, concrete or block work unless approved by the Engineer.
- xxi. Approved proprietary expanding masonry bolts/resin anchor bolts shall be used where shown on the drawings, specified or instructed by the Engineer and shall be of a type, size and strength suitable to their location and function and fixed in strict accordance with the manufacturer's printed instructions.

2. JOINERY

2.1 Timber Generally

Comply with Clause 1.1.

2.2 Moisture Content

Comply with Clause 1.2

2.3 Preservatives

- i. Comply with Clause 1.3
- ii. With regard to Clause 1.3(iii) specified treatment shall be carried out prior to assembly of pieces.

2.4 Hardwood

Comply with Clause 1.4.

2.5 Softwood

Comply with Clause 1.5 except all softwood shall be free from knots exceeding 6mm diameter.

2.6 Plywood

- i. Comply with Clause 1.6.
- ii. Face veneers shall closely match the general joinery timber unless described otherwise and shall be approved by the Engineer prior to inclusion in the Works.
- iii. Plywood for joinery work shall be Grade I or A on both face unless otherwise shown, specified or approved.

2.7 Block board

- i. Block board shall comply with BS 3444 and be manufactured by approved process with hardwood veneers, minimum 3 mm thick, to both faces.
- ii. Clause 2.6 (ii) applies in respect of visible faces of block board.
- iii. Full sheets shall have edges lipped with matching hardwood 6 mm thick, the full thickness of the sheet.

2.8 Decorative Laminated Plastic Sheet

- i. Decorative plastic sheet shall be amino plastic faced phenolic resin laminated veneer to BS 3794 Class 1 or a comparable alternative to the Engineer's approval.
- ii. The laminate shall be minimum 1.5 mm thick with decorative finish on one face only to the manufacturer's standard colour, pattern and texture as shown, specified or approve by the Engineer.

2.9 Adhesives

Adhesives shall comply with Clause 1.8.

2.10 Doors

- i. All timber doors shall be solid core type unless specified otherwise and to the size, thickness and pattern as shown on the drawings/schedules.
- ii. Timber for construction shall be as specified within this section.
- iii. Plywood for door facings shall comply with Clause 2.6, and shall not be less than 3mm thick.
- iv. Plywood facings for painted finish doors shall be Grade 1 or A to seen faces.
- v. Unless specified otherwise doors shall be hardwood lipped on all edges to the full width between finished faces minimum 15 mm thick.
- vi. Glazed apertures shall be in accordance with Section M and as detailed on the drawings and shall be framed in hardwood to match edge lipping with matching, screw fixed beading.
- vii. Adhesives for facings and door construction shall comply in all respects with BS 1203, BS 1204 or BS 5442 Part 3 as appropriate.
- viii. When described as "fire check" or "fire resistant" doors and frame assemblies shall be constructed to pass the fire tests described in BS 476 Part 20-22:1987 for the periods stated on the drawings/schedules.
- ix. Where indicated on the drawings/schedules approved intumescant seals shall be let into grooves on all edges of fire doors/frames fixed in strict accordance with the manufacturer's printed instructions and to comply with Clause 2.10(vii).

2.11 Mechanical Fastenings

- i. Mechanical fastenings shall comply with Clause 1.7 (iii).
- ii. Nails shall be to BS 1202 and shall be lost headed nails, suitable for stopping when used

for decorated work.

- iii. Screws shall be to BS 1210 and shall be stainless steel or brass where specified.
- iv. Cups for screws shall be brass or stainless steel heavy pressed socket pattern.

2.12 Fittings

Materials and workmanship for metal glass, etc. forming an integral part of joinery items shall comply with the appropriate section of this specification.

2.13 Workmanship

- i. Where Clause 1.10 is applicable to elements of joinery work the requirements of that clause shall be complied with.
- ii. Joinery shall comply with the requirements of BS 1186 Part 2, shall be accurately, properly and soundly fabricated in a manufacturer's workshop.
- iii. Fixing of all joinery work, including fillets, architraves, frames, glazing beads and the like shall be by means of screws unless specifically approved by the Engineer.
- iv. The terms "frame", "framed" or "framing" shall mean work put together by dovetailing, dowelling, etc., and the joints are to be as shown, specified or directed.
- v. 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.
- vi. Cutting of plywood and block board shall be neatly and accurately performed with fine tooth saws so as to avoid splitting the face veneers, or intermediate plies.
- vii. Where raw edges arise from cutting block board these shall be lipped with hardwood to match factory produced edges.
- viii. Plastic laminate shall be fixed with an approved adhesive in accordance with BS 1203 and BS 1204 Part 1.
- ix. Care shall be taken on fixing plastic laminates to eliminate all air from beneath the laminate and if air is entrapped the portions and work so disfigured shall be removed and replaced.
- x. After complete setting of the adhesive the plastic laminate shall be neatly beveled along all arrises with a plane.
- xi. Where plastic laminate is fixed to doors or shelves, etc., without laminate to the outer edge, a raised lipping is to be provided and the laminate finished flush against the lipping.
- xii. Where block board and plywood are specified to have a laminated plastic sheet, a balancing veneer of the same material and thickness shall be bonded to the back.
- xiii. Unless secret fixing is practicable or otherwise described, clear finished hardwood shall be fixed using non-ferrous or paltes screws with heads let in and pelleted with grainmatched pellets of minimum 6 mm thickness cut from the same timber.
- xiv. Built in fittings etc., are to be accurately constructed in accordance with the detailed drawings and doors, drawers, etc. shall fit and open and close smoothly and all work next to walls, floors and ceilings or other fixed items shall be soundly fixed and scribed to fit snugly against same.
- xv. Mouldings shall be worked on the solid unless otherwise stated and shall be accurately worked to the drawings.
- xvi. When circular work is shown on the drawings or specified it shall be built up with an appropriate number of pieces, cut to the required shapes, which shall be put together in two or three thicknesses so that they break joint, and shall be secured with hardwood keys and

wedges or with hardwood pins, whichever is more appropriate.

- xvii. Skirting, architraves, plates and other joinery works shall be accurately scribed to fit the contour of any irregular surface against which they will be required to form a close butt connection.
- xviii. Doors shall be properly hung within frames/linings to give a uniform clearance.
- xix. Hardwood veneers shall be the species described or specified and shall be selected pieces free from splits, dots, stains, insect and fungal or any other natural or man-made defects.
- xx. Glass or synthetic fibre stitching will not be permitted for jointing veneer leaves together and filling or inlaying shall be avoided.
- xxi. All wood veneers shall be bonded to the core material with the approved adhesives such that no lifting or blistering shall occur.
- xxii. The method of construction must accommodate tolerances as shown on the drawings and allow for ensuring that repetitive units can be accurately located in relation to grid lines or other setting out points and that tolerances do not accumulate.
- xxiii. Reasonable tolerances shall be provided at all junctions between joinery and the building carcass, whether of masonry or frame construction, so that any irregularities or movement shall be adequately accommodated.
- xxiv. All joinery shall be left finished smooth and clean by rubbing down by hand with fine glass paper.
- xxv. Should any joints or moving parts in joinery fit other than accurately and evenly or with acceptable clearances or should any defect of timber become apparent, the joinery shall be repaired or replaced as directed by the Engineer.

3. IRONMONGERY

- i. Ironmongery shall be of the pattern and finish as shown on the drawings/schedules or as specified and obtained from approved manufacturers, delivered in protective packaging, clearly labeled and stored in secure store.
- ii. Hinges and other items to be fixed flush with the timber shall be located within accurately formed housings of suitable path.
- iii. All ironmongery shall be fitted firmly into its housing or surface mounted as appropriate with matching screws or other fixings in accordance with the manufacturer's printed instructions and to enable its proper and easy operation.
- iv. Where possible ironmongery shall be fixed as final operation or shall be removed and re-fixed as necessary to facilitate decoration or other work.
- v. Where indicated on the drawings/schedules approved draught/dust seals shall be installed in strict accordance with the manufacturers printed instructions.
- vi. All ironmongery shall be properly eased, adjusted, lubricated and cleaned on completion and left in good working order all the Engineer's approval.
- vii. Locks shall be suited as indicated on the drawings/ schedules and all keys, with one duplicate shall be adequately labeled and handed to the Engineer.

4. SAMPLES

The contractor is required to submit cut away samples of doors, kitchen furniture, architraves & the ironmongers as specified, showing core construction, veneer & plywood for doors. No order shall be made to the manufacturer prior to approval of samples.

5. SHOP DRAWINGS

The Contractor shall submit shop drawings of items specified herein to the Engineer for approval prior to proceeding with manufacturing of same. The shop drawings shall indicate the arrangement, patterns, thickness, size of elements, mouldings, profiles and the like, size of openings in doors, face veneers, core construction, etc.

KERB AND PAVING

1. SCOPE

This Section covers the requirements for materials and workmanship for the installation of kerb and paving surfaces.

2. GENERAL

2.1 Related British Standards and other references:

BS 435:1975 (1993)	:	Specification for dressed natural stone kerb, channels, quadrants & sets
BS 5931:1980	:	Code of practice for machine laid, in situ edge details for paved areas
Part 1:1986	:	Specification for pavers
Part 2:1986	:	Code of practice for design of lightly trafficked pavements
Part 3:1986	:	Method of construction for pavements
BS 6717	:	Pre-cast concrete paving blocks
Part 1:1993	:	Specification for paving blocks
Part 3:1989	:	Code of practice for laying
BS 7263	:	Pre-cast concrete flags, kerb, channels, edgings and quadrants
Part 1:1990	:	Specification
Part 2:1990	:	Code of practice for laying
BS 7533 : 1992	:	Guide for structural design of pavements constructed with clay or concrete block pavers

Latest editions of all relevant British Standards shall be used with current amendments and additions.

Any differences between their requirements and this specification shall be submitted to the Engineer for his ruling.

2.2 Levels, ref. Points and setting out

The works are to be set out from primary datum levels and setting out points indicated on the drawings or from information provided by the Engineer

The contractor shall submit his proposals for setting out and controlling the alignment of the works, to the Engineer and obtain his approval prior to the start of construction. The Contractor shall supply to the Engineer details of the value and location of all temporary benchmarks and reference points he establishes.

Should the Contractor dispute the original ground levels shown on the drawings he shall agree these with the Engineer before disturbing the original ground

2.3 Related work

Carefully examine all of the Contract Documents for requirements which affect the work of this section

2.4 Quality Assurance

Source: Provide kerb/paving units, which are the products of one supplier and one quarry as specified. Stone material shall comply with the standards of the National Granite Quarries Association (NGQA)

Mock-ups: Before beginning primary work of this section, provide mock-ups of paving & edging types (min. area 2.0m x 2.0m) at locations acceptable to the Engineer and obtain Engineer's acceptance of visual qualities. Protect and maintain acceptable mock-ups throughout the work of this section to serve as criteria for acceptance of this work. Acceptable mock-ups may be incorporated into finished work.

2.5 Submittals

Product Data:

Submit manufacturer's product data, installation instructions, use limitations and recommendations. Provide certifications stating that materials comply with requirements.

Verification Samples:

Submit representative samples of each element that is to be used in the finished work, showing the full range of colour and finish variations expected. Provide at least four un-mounted units.

Provide large scale shop drawings for fabrication and installation of all kerb/paving work to include plans and details showing exact size, shape, profile, curvature, finish and installation method.

2.6 Delivery, Storage and Handling

Deliver, store and handle kerb/paving units in strict compliance with manufacturer's instructions and recommendations. Store above ground and protect from damage and soiling.

2.7 Project conditions

Weather: Perform work only when existing and forecasted weather conditions are within the limits established by International Masonry All-Weather Council Guide Specification and the mortar admixture manufacturer.

2.8 Substrates

Proceed with work only when substrate construction and work is complete.

2.9 Extra material

Provide wrapped, packed and labeled extra material consisting of three (3) pieces of each type, size and configuration of stone used on the Project. Deliver to the location designated by the Engineer.

3. MATERIALS

3.1 General

Where materials used in this section have been specified elsewhere in this document, the relevant clauses shall apply to this section. Materials that have not been individually specified shall be of first class quality and the minimum standard acceptable shall be the relevant British Standard where applicable.

White cement

White cement shall be obtained from an approved manufacturer and shall comply with the relevant British Standard.

Mortar / Grout Materials for granite paving

- (i) Portland Cement: Provide ASTM C - 150 Portland Cement, Type I or II, of natural color or white as needed to produce color selected.
- (ii) Hydrated Lime: ASTM C 207, Type S.
- (iii) Aggregates: ASTM C 144 and as indicated below:
 - a. For joints narrower than 6 mm use aggregate graded with 100 % passing the No. 8 sieve and 95 % the 16 sieve.
 - b. For pointing mortar, use aggregate graded with 100 % passing the No. 16 sieve.
- (iv) Coloured Mortar/Grout Pigments: Natural and synthetic oxides and chromium oxides, compounded for use in mortar mixes. Use only pigments with record of satisfactory

performance in stone mortars. Colour shall be selected from the full range of manufacturer's standard colours and shall be to Engineers approval.

- (v) Water: Clean, non-alkaline, potable. Do not use water in latex modified grout or mortar mixes.

3.2 Pre-cast Concrete kerb

Pre-cast concrete kerb, channels, edgings and quadrants shall comply with BS 340 and shall be hydraulically pressed. They shall be laid and bedded on a Class II mortar bed not less than 10 mm and not more than 40 mm thick on a foundation of concrete Grade 20.

For radii of 12m or less appropriate radius kerb shall be used. Short, straight sections of kerb shall not be used for these radii without the Engineer's prior approval.

Before backing with concrete the kerb-line shall be checked for line and level and the foundation shall be thoroughly cleaned and wetted. Any units deviating by more than 3 mm in 3m from line and level shall be taken up and re-laid. The level of any part of the kerb-line shall not deviate by more than 3 mm vertically from the specified level.

Where filling behind the kerb is likely to have harmful effect the kerb, backing and foundation shall be protected by a method agreed with the Engineer or as shown on the Drawing.

Joints between pre-cast units are to be left open. Expansion/contraction joints are to be at 6m centres in foundation and backing and are to be 3 to 5 mm wide.

3.3 Pre-cast concrete paving blocks

Cement:

The cement used in the manufacture of pre-cast concrete paving blocks shall comply with the requirements of either BS 12, 4027 or BS 146.

The cement content of compacted concrete shall not be less than 400 kg/cum

Aggregates:

The aggregate shall consist of naturally occurring crushed or with BS 882. The salt contents shall not exceed the following limits:

Acid soluble Chlorides:	0.06% by wt of Fine Aggregates 0.02% by wt of Coarse Aggregates
Acid Soluble Sulphates:	0.3% by wt of Fine and Coarse Aggregates

Water:

The water shall be clean and free from any deleterious matter having pH value in the basic range (7.9). The inorganic impurities shall not exceed the following limits:

Total dissolved solids	2000 mg/litre
Chlorides	600 mg/litre
Sulphates	500 mg/litre
Alkali Carbonates & Bicarbonates	1000 mg/litre

Pigments:

Any pigments used shall comply with BS 1014.

Dimensions & Tolerances:

Standard rectangular blocks shall be manufactured with a nominal length of 200 mm and a nominal width of 100 mm. Alternative sizes and shapes shall have a ratio of length to width on plan of not less than 1 /12 or greater than 2 ½; the width shall not be less than 80 mm or greater than 115 mm. The minimum normal thickness for paving blocks of any size shall be 60 mm. The preferred nominal thickness shall be 60, 80 and 100 mm.

All arises shall be clean, plane and of uniform dimension. Wearing surface areas shall not be less than 70% of the plan area.

Tolerances:

Length	+	2 mm
Width	+	2 mm
Thickness	+	3 mm

Compressive Strength:

The average compressive strength of the block on delivery when sampled and tested in the manner described below, shall be not less than 49 N/sq mm in wet conditions. No individual block strength shall fall below 40 N/sq mm in wet conditions.

Correction factors for chamfers and thickness shall be

Block Thickness m	Plain Block	Chamfered Block
60/65	1.00	1.06
80	1.12	1.18
100	1.18	1.24

Sampling Blocks:

Two blocks shall be drawn from each group of 1000 blocks for sampling 10 blocks every designated section or part thereof in a consignment. All samples shall be clearly marked at the time of sampling in such a way that the designated section or part thereof and the consignment represented by the sample, are clearly defined.

Test for Compressive Strength.

The sample specimens shall be tested in a wet condition after being stored for at least 24 hours in water maintained at a temperature of 27 degrees Celsius + degrees Celsius. Before the specimens are submerged in water, the necessary area shall be determined as follows:

Where possible the plan area or the wearing surface area shall be calculated by multiplying the length by the width.

Alternatively the plan area or the wearing area shall be calculated by cutting out shapes of cardboard and weighing it to the nearest 0.01g.

$$A_s = \frac{m_s}{m} \times 20000 \text{ msm}$$

Where A_s =Area of block (sq mm) m_s = Mass of cardboard shape matching test block (g); the block shall be placed wearing surface uppermost on the cardboard. m = Mass of 200 x 100 mm cardboard rectangle (g) cut from the same cardboard.

In case of chamfer or radius, the width of chamfer or radius shall be measured and marked on the cardboard shape. This shape shall then be cut out accurately and weighed for calculation of the wearing surface area. Plywood, normally 4 mm thick, shall be used as packing between the upper and lower faces of the specimen and the machine platens, and these boards shall be larger than the specimen by a margin of at least 5 mm at all points. Fresh packing shall be used for each specimen tested.

The load shall be applied without shock and increased continuously at a rate of approximately 15 N/sq mm per minute until no greater load can be sustained. The maximum load applied to the specimen shall be recorded. The strength shall be expressed to the nearest 0.1 N/sq. mm.

Test for Water Absorption

Blocks shall be tested for water absorption in accordance with BS 1881. Blocks shall be deemed acceptable provided that the maximum absorption does not exceed:

- 2% after 10 mins
- 5% after 24 hours

Certificate of Compliance

This certificate is to be provided by the manufacturer at the time of sale as per item No. 12 of BS 6073 where the independent laboratory mentioned therein shall be the Municipality Construction Quality Control and Research Section.

3.4 Natural stone for boulders, cobbles and gravel

All natural stone to be light red/brown in colour. Contractor to provide a range of samples from each different area for the Engineers approval

Natural stone for steps to be:

- Selected for natural appearance - colour : light - med. red/brown with flat top and underside faces
- No drill holes, chisel marks or saw cuts
- size: 400 – 800 mm nominal diameter; 50 mm thick slabs
- Steps to be located to the approval of the Engineer
- Contractor to allow for the preparation of a minimum of 3 no. steps placed in final locations for the Engineers approval

Natural stone for decorative groupings to be a mixture of boulders, cobbles and gravel:

Boulders:

- Selected for natural appearance - colour : light - med. red/brown
- No drill holes, chisel marks or saw cuts
- Size - boulders to be supplied in a range of sizes from 400 mm dia. – 1200 mm dia. (Tonnages shown on drawings)
- Boulders to be located to the approval of the Engineer

Cobbles:

- Water worn and selected for natural appearance - colour: light - med. red/brown
- Size - cobbles to be supplied in a range of sizes from 100 – 300 mm dia.
- Cobbles to be placed to the approval of the Engineer. Size ranges to decrease from boulders

Gravel:

- Water worn (not crushed) - colour : light - med. brown
- Size - gravel to be provided in the following size ranges :

10 - 20mm dia.	70% by area (including all mulched areas)
20 - 100mm dia.	30% by area
- Gravel to be placed to a minimum depth of 50mm to the approval of the Engineer

3.5 Granite kerb and paving

Granite paving shall be from an approved supplier.

Sizes: Provide as indicated on the drawings and as specified below:

Granite slab paving within pedestrian areas and cladding - 3 centimeters thick

Granite setts - 200 x 100 x 100 or 100 x 100 x 100

Granite shown on drawings to occur in radiused patterns shall be fabricated in a curved shape to conform to the radii shown on the drawings.

Mortar / Grout Materials for granite paving

Portland Cement: Provide ASTM C-150 Portland Cement, Type I or II, of natural

colour or white as needed to produce colour selected.

Hydrated Lime: ASTM C 207, Type S.

Aggregates: ASTM C 144 and as indicated below:

For joints narrower than 6mm use aggregate graded with 100 % passing the No. 8 sieve and 95 % the 16 sieve.

For pointing mortar, use aggregate graded with 100 % passing the No. 16 sieve.

Coloured Mortar / Grout Pigments: Natural and synthetic oxides and chromium oxides, compounded for use in mortar mixes. Use only pigments with record of satisfactory performance in stone mortars. Colour shall be selected from the full range of manufacturer's standard colours and shall be to Consultants approval.

Water: Clean, non-alkaline, potable. Do not use water in latex modified grout or mortar mixes.

Mortar Materials: Provide latex modified Portland cement thick-bed mortar to comply with directions of latex additive manufacturer and as necessary to produce stiff mixture with a moist surface at time stone is set.

Thick-set mortar latex additive: Laticrete 3701 Mortar Admix or equal and approved

Adhesive coat: Laticrete Latex Thinset Mortar Additive 4237 with 211 Crete Filler Powder or equal and approved

Bond coat: Laticrete 4237 Latex Additive with 211 Crete Filler Powder or equal and approved
Thick bed mortar reinforcing mesh: to Consultants approval

Grout Materials: Provide latex modified Portland cement, factory blended grout to comply with directions of latex additive manufacturer.

Grouting mortars shall be Laticrete Dry-set Grout or equal and approved
Dowels: Stainless steel to Consultants approval

3.6 Insitu concrete paving

Insitu concrete paving shall be made with white cement and nom. 3-5 mm white quartzite aggregate to Engineers approval colour pigmented to light red/pink colour or light brown/tan colour as shown on the drawings finished by lightly sandblasting (sweet blasting) to achieve a uniform appearance construction joints to be 5 mm, edges to be rubbed down to a small 2-3 mm chamfer

3.7 Sandstone

e Sandstone paving shall be Indian Dhofur as follows : colour and texture - buff colour, honed finish crushing strength : 48.0 MN/sq.m mass density : 2220 kg/cu.m

water absorption : 9.6%

acid immersion test : pass

saturation coefficient : 0.64%

Size to vary, all square edged and cut to a random pattern within a 4.0 m x 4.0 m module. Max. size : 900 x 900, Min. size 300 x 300. All sandstone to be 50 mm thick unless otherwise specified. Samples of typical module to be produced for Consultants approval. Sandstone to be bedded on 25mm mortar bed, mortar mix to manufacturers recommendations. Contractor to allow for providing samples of specified stone and others that meet the technical specification and for the construction of 3.0m x 3.0m panels of selected sample pieces for Consultants approval.

All stone paving to be sealed with approved sealant after laying. Sealant to be applied in strict accordance with manufacturer's instructions.

4. WORKMANSHIP

4.1 Pavement construction - Sand bedding

- The sub-grade shall be prepared in accordance with the manufacturer's printed recommendations.
- Granular sub-base shall comprise natural stone, crushed rock or gravel. The material shall have a ten percent fines value of not less than 50 kN when tested in accordance with BS 812, shall be well graded and lie within the following grading envelope:

BS Sieve size		SUB BASE percentage by mass passing
63 mm	:	100
37.5 mm	:	85-100
10 mm	:	40-70
5 mm	:	25-45
600 microns	:	8-22
75 microns	:	0-10

The particle size shall be determined by Test 7A of BS 1377.

The sub-base shall have a minimum soaked CBR value of 30% at 95% of the maximum dry density as determined by the Test 16 of BS 1377, and the material passing the 425 micron BS sieve shall be non-plastic, when tested in accordance with BS 1377.

The material shall be compacted to a field density not less than 95 per cent of the maximum dry density determined by the vibrating hammer test method of BS 1377. Field density tests shall be carried out at a frequency of 2 tests per 1000 sq m laid and one test per 150 metre of shoulder, or as directed by the Engineer.

The laying course shall consist of sharp sand to BS 882 with a particle size of 4 mm containing not more than 3% silt and/or clay by weight. The sand shall be obtained from a single source, allowed to drain before use, and shall be covered with suitable sheeting to minimize moisture changes. Permissible sulphate and chloride contents shall not exceed 0.4% and 0.06% respectively (expressed only as SO₃ and C1 by weight).

Pre-cast paving blocks used for pedestrian footpaths will be laid to a herringbone pattern. The direction of the pattern shall be maintained throughout the total area to be paved. Any change of direction will require the approval of the Engineer.

The laying course shall be laid to compacted thickness of 50 mm plus a surcharge necessary to provide the specified final bed thickness after vibration of the block paving. During laying the sand shall be carefully screeded to a smooth surface to receive the paving blocks. No compaction of the sand layer and no traffic including pedestrian is to be permitted before the blocks are laid.

The profile of the laying course shall be similar to that of the finished surface. The maximum deviation from the design levels shall be + 10 mm. The edge restraints to the paved area shall be laid in advance of the laying course and all obstacles within the area, such as manhole covers, shall be constructed to the correct finished levels.

The paving blocks shall be laid on the sand laying course in such a manner as not to disturb the blocks already laid. Each block shall be placed firmly against its neighbors so that they fit closely together.

The joints between blocks shall not exceed 3 mm.

Where blocks do not fit at the edge, restraints or other obstructions such as manholes or upstands the gaps shall be filled using cut blocks. Blocks shall only be cut using a saw.

Any damaged or broken blocks shall not be laid. Any blocks damaged during compaction shall be replaced at the discretion of the Engineer

Due allowance shall be made in the final levels of the base for the compaction of the laying course above, which occurs when the paving blocks are being vibrated. The amount of surcharge required for the laying course shall be determined by site trials prior to the commencement of the actual surfacing and shall be repeated when the source of sand supply or a change of weather conditions occurs.

After each 20 sq m or such area that has been agreed with the Engineer, has been laid the blocks shall be compacted to the required levels using a plate vibrator.

The plate vibrator shall have a plate area of 0.20 to 0.35 sq.m. and have a compaction force of 12-24 kN and a frequency of approximately 75-100Hz.

A minimum of two passes of the plate vibrator shall be made in each direction, i.e. at 90 degrees to each other. Vibration shall continue until no further compaction of the sand layer is apparent. Fine dry sand with particle size of 0.3 mm shall then be brushed over the paving and further passes of the plate vibrator made in each direction, until the sand is no longer absorbed into the joints.

The plate vibrator shall not pass closer than 1m to a temporarily unrestrained edge during laying. No paving shall be left un-compacted overnight except for the one metre strip at the temporarily un-compacted edge, which shall be covered and protected from rain.

On completion, the finished surface level shall be within 5 mm of the design level and the maximum deviation within the compacted surface, measured by a 3m straight edge, shall not exceed 5 mm. The level of any two adjacent blocks shall not differ by more than 2 mm. Any areas of paving which do not comply with these tolerances shall be removed, and sand laying course lifted and re-laid and the paving blocks re-laid to the correct levels.

Dimensional accuracy, uniformity of joint gaps, alignment and squareness shall be checked after paving the first three rows of blocks and thereafter at regular intervals. If joints begin to open the blocks shall be knocked together using a hide mallet.

4.2 Pavement construction - Mortar bedding

Examination Examine surfaces to receive stone specified under this section, and conditions under which stone will be installed, with installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of stone work. Do not proceed with installation until unsatisfactory conditions have been corrected. The stone installer shall be fully responsible for accepting the condition of such surfaces prior to initiation of work.

Ensure that surfaces to receive stone are firm, dry, clean, and free of oily or greasy films, mortar, soil, and other foreign substances.

Installation

Strictly comply with supplier's and manufacturer's instructions and recommendations, except where more restrictive requirements are specified in this section.

Clean sub-base to remove dirt, dust, debris and loose particles.

Do not use damaged, chipped or defective paving units. Where blocks/slabs do not fit at the edge, restraints or other obstructions such as manholes or upstands the gaps shall be filled using cut blocks/slabs. Pavers shall only be cut using a saw - no guillotine cutters shall be allowed on this site. Any damaged or broken blocks/slabs shall not be laid.

Any blocks/slabs damaged during compaction shall be replaced at the discretion of the Engineer. Use full, uncut units to the greatest extent possible. Beginning work means Installer accepts substrates and conditions.

Install pavers in full mortar bed and dowel to substrate conforming to the requirements below.

Prepare setting bed over sub slab - Portland Cement Concrete Paving.

Mix and prepare mortar in compliance with mortar/ grout manufacturer's instructions and recommendations. Compact setting bed and screed to proper depth so that tops of pavers will be level with grades and as indicated on the drawings.

Saturate concrete sub base with clean water several hours before placing setting bed.

Remove surface water about one hour before placing setting bed.

Spread and screed setting bed to a uniform thickness at sub grade elevations required for accurate setting of stone paving to finish grades indicated. Mix and place only that amount that can be covered with stone prior to initial set.

Cut back, level edge, and remove and discard mortar that has reached initial set prior to placing stone.

Wet stones thoroughly before setting. Set pavers in patterns approved by Consultant. Lay pavers symmetrically about centerlines. Provide no larger than 6 mm grout joints between pavers. Set stones before initial set of mortar bed occurs. Do not set stone on dry bed. Apply uniform 1.6 mm thick slurry bond coat to bed or back of stone with a flat trowel just prior to placing stones on green or wet setting bed.

Pound pavers into place with heavy rubber mallet to obtain full contact and adhesion with setting bed. Do not disturb pavers after setting. Remove and relay pavers that must be adjusted.

Tolerances: Maintain an allowable installed tolerance of +3 mm in 3 m. No ponding of water will be permitted.

Stone edge-to-edge alignment: + 0.8 mm at any location.

Face width of joints: + 0.6 mm at any location.

Mix, install and cure grout in strict compliance with mortar/grout admixture manufacturer's instructions and recommendations. Coloring agent to be added to the grout to the approval of the Engineer.

Expansion and Control Joints: Provide 9.5 mm wide sealant filled joints in compliance with relevant Specification. Provide sealant filled expansion joints over all cracks and joints in concrete sub slabs, over all changes in backing materials, where stone abuts a restraining surfaces such as walls, columns, planters, and dissimilar walking surfaces, all to Engineers approval.

Grout joints as soon as possible after initial set of setting bed. Force grout into joints, taking care not to smear grout on adjoining exposed stone surfaces. After grout initially sets, tool joints slightly concave. Cure grout by maintaining in damp condition for 7 days except as otherwise indicated by latex additive manufacturer. Pointing shall be flush unless otherwise specified. Prohibit traffic on paving and steps during setting or within 24 hours after initial grouting of joints.

4.3 Repair and cleaning

Remove and replace loose, chipped or broken pavers. Clean exposed surfaces using materials and methods recommended by pavers manufacturer. Remove and replace work that cannot be successfully cleaned.

4.4 Protection of paving

The Contractor shall include in his rates for paving for adequately protecting all surfaces to the satisfaction of the Engineer until Substantial Completion of the whole of the Works. The Contractor shall include in his rates for paving for adequately protecting all surfaces to the satisfaction of the Engineer until Substantial Completion of the whole of the Works.

ELECTRICAL WORKS

ELECTRICAL WORKS

1. SCOPE OF WORK

The Electrical Contractor shall Design the complete electrical system and supply all labor, materials and equipment necessary for the complete installation, testing and commissioning of the entire electrical works which shall broadly include but not limited to the following as per specifications, drawings and shall prepare detailed bills of quantities and shall submit them duly filled, signed and stamped on all the pages with his quotation.

- a. LT panels, LV distribution boards, MCB DBS disconnect switches/circuit breakers, motor starters etc.
- b. Power cables (HT & LV)
- c. Wiring for light, fan and socket outlet
- d. Wiring accessories (switches, sockets, computer, telephone outlets etc.)
- e. Lighting fixtures, fans
- f. Cable Trays / Trunkings / Pipes/Pull boxes
- g. Structured Cabling (passive works)
- h. Earthing system(s)
- i. Lightning Protection System
- j. Fire Alarm System
- k. Compact (sandwich) busbar trunking (Busway)
- l. Wiring & Power Supplies to HVAC System
- m. Wiring & Power Supplies to Plumbing Pumps Etc.
- n. Elevator & Dumb-waiters
- o. 11KV Switches
- p. Power Transformers
- q. Power Factor improvement plants
- r. Diesel Generators
- s. Testing & Commissioning

2. GENERAL

The entire electrical installation shall be carried out by an approved licensed Electrical Contractor authorized to undertake such works.

All works are to comply with the latest Edition of the IEE Regulations for Electrical Installations UK, the Electricity Act 1910, the Electricity Rules 1937, and in accordance with the requirements of the local inspector, the utility supply authorities (K.E./Pakistan Telecommunication Corporation), Contract Drawings/specifications, BOQ and to the satisfaction of the Consultant/Owner.

3. APPROVAL FROM ELECTRICAL INSPECTOR

The Contractor shall be responsible for completing all formalities such as serving notices, submitting drawings / documents and obtaining all permits, sanctions, connections and having the installation passed and commissioned by the relevant authorities and obtain an approval certificate from the concerned Electrical Inspector's Office for the total load of the premises including the load of HVAC machines elevators, pumps, etc. All costs involved in obtaining such permits, sanctions, approvals from the concerned authorities are deemed to be included in the contract price and no extra payment shall be made to the Contractor.

4. STANDARDS

All materials and equipment such as distribution boards, cables/wires, conduits and conduit accessories, wiring accessories (switches, sockets, dimmers etc.) Circuit breakers, switch boxes lighting fixtures, lamps etc. are to comply with the specifications, the relevant British Standards, Pakistan Standards Institute and underwriters laboratories requirements or equivalent IEC, DIN Standards & NEC Standard. In general, following standards & codes of practices shall be followed.

- a) Relevant BS specifications and codes of practices and IEC publications and DIN standards. Mentioned below, but not limited to them.
- b) NFPA/ National electric code.

- c) BS 6121: Mechanical cable glands
- d) BS 6346 specification for 600V/1000V & 1900/3300 V armored electric cables having PVC insulation.
- e) IEC 60034: Rotating electrical machine
- f) IEC 60287: Electric cable- calculation of the current rating.
- g) BS 7671: Requirements for electrical installations
- h) IEC 60909: Short circuit current calculations in 3 phase a.c system.
- i) NFPA 72E: automatic fire detector
- j) ERA: current rating standards 69-30 parts 5,6,7.
- k) Electricity Act 1937

Samples of all materials / equipment are to be submitted to the Architect / Consultant / Owner for approval before purchase or fabrication / installation.

5. SHOP DRAWINGS

The locations, routings, and installation heights of electrical equipment, conduits cable trays etc. given on the design drawings are approximate. Based on site conditions and in coordination with civil and mechanical drawings the contractor shall prepare shop drawings showing proposed routes of conduits and positions of equipment, including mounting and fixing details and submit the same to Owner/ Construction Manager/ Consultant for approval. Five sets of drawings (hard & soft copy) and technical literature/ brochures for all the electrical equipment / systems are to be submitted four weeks in advance of the execution of the works and approval obtained before execution / installation of works.

6. DRAWINGS OF LV SWITCHGEAR/DISTRIBUTION BOARDS

The Contractor is required to submit the preliminary drawings of LV switch gear, Main Distribution Board, PFI Plant and associated Distribution / Computer Distribution Panels from one of the approved manufacturer to the Project Manager/ Consultant/ Owner for approval. These drawings will be issued for construction after getting written approval from the Owner.

7. DESIGN CALCULATION COMPLYING WITH INTERNATIONAL STANDARDS

Technical specification of material as mentioned shall be considered, but not limited to it. A high standard quality and high standard works shall be achieved, which shall be supported with proper calculations of the design for all installations and having reference to international standards for such type of installations. All design calculation and reference are to be submitted to consultants for review / approval, prior to ordering & installation of material / equipment at site.

8. CLIMATIC CONDITIONS

Equipment and materials supplied shall withstand under all conditions of continuous operation and without developing any defects, the following environmental conditions.

Maximum temperature	:	40 deg. C
Minimum temperature	:	-12 deg. C
Relative humidity	:	90 %
Location	:	_____.

9. EQUIPMENT PROTECTION

Unless otherwise stated all equipment supplied shall conform as a minimum to the following protection classes:

Indoor	I.P. 40
Outdoor	I.P. 54 or 65 as applicable

Certification from manufacturer is required / to be submitted.

10. FACTORY INSPECTION OF LV SWITCHGEAR/ PANELS

The Contractor will arrange a visit of Consultants / Owner/ Construction Manager for the Inspection/ testing of LV Switchgear. Distribution / Computer distribution boards, PFI plant etc. at the Manufacturer's premises before delivery the items to site. The Owner/ Project Manager will

have the right to object/ reject any substandard material/ panel found to be unsuitable or not in accordance with the specifications. The Contractor will be required to replace the substandard material and rectify the defect objected by the Consultants/Owner/ Project Manager at his own cost.

11. TESTING AND COMMISSIONING

During execution and on completion of the works, (as required by Consultant / Owner / Project Manager) the following tests shall be performed and a satisfactory performance certificate in respect of each test shall be submitted with the final bill. All equipment/instruments for the tests are to be provided by the Contractor at no extra cost. All tests to be performed in the presence of Consultant / Owner or its representative Engineer.

- a) Earth Resistance test and earth loop impedance test.
- b) Insulation resistance / Megger test of the entire electrical installation between phases, phase to earth and phase to neutral.
- c) Polarity tests on switches, MCB's, fuses, etc.
- d) Operation tests and commissioning of the entire electrical installation including all equipment.
- e) Lux level measurement of each area

Certificates of Test shall be compiled, for each section of the installation. A master set of these documents shall be kept as the original of the Test Dossier. This dossier will bear the signature of Owner witnessing the tests.

12. MAINTENANCE AND WARRANTY

The Contractor shall be responsible for the entire electrical works and all equipment supplied by him and warrants the same for a period of twelve months from the date of the completion certificate. Any defect due to the workmanship or equipment failure shall be replaced by the Contractor free of charge during that period.

13. AS-BUILT DRAWINGS

On completion of the works the Contractor shall supply one reproducible and three copies of as-built drawings which clearly indicate all amendments, junction boxes, pull boxes, etc. These shall be provided at no extra cost. The as-built drawings shall indicate the entire electrical installation as actually carried out on site including telephone, fire alarm, sound system, computer system, electrical wiring, LV switchgear panels, distribution panels, PFI plant & electrical works of building etc and schematic diagrams.

14. SITE CONDITIONS

The Contractor shall visit the site before submitting his quotation and acquaint himself with the site conditions, and check the specifications, design drawings and the bill of quantities.

Omissions/errors, if any, are to be brought to the attention of the Consultant or included in the bid. After award of the contract no claims shall be entertained.

15. OPERATION AND MAINTENANCE MANUALS

The Contractor shall submit four sets of manuals & wall mounted charts for all the electrical equipment supplied and installed by him which shall include detailed operation and maintenance instructions for each item as recommended by the manufacturer. These manuals shall be submitted on completion of the works.

16. ASSOCIATED CIVIL WORKS

The cost of any civil works, (cutting, chiseling, excavation, backfilling, grouting, drilling etc. and making good) associated with any item of the electrical works shall be included in the quoted price for the item. The Contractor shall be responsible for carrying out these civil works and making good and the cost shall be deemed to be included in the quoted price.

The Contractor shall take care not to damage the structure during execution of his work. If so done, he shall repair and make good all losses at his own cost.

17. CONDUIT AND CONDUIT ACCESSORIES

Wiring shall generally be in PVC conduit for electrical use minimum 20mm diameter, minimum wall thickness 1.25mm, concealed in structural slab, wall or screed with at least 50mm cover or clipped to the surfaces with metallic saddles, as required. All conduit accessories shall be of the same quality as the conduit. Saddles for fixing conduit on surface shall be provided at 1000 mm spacing.

No conduit shall be laid in the light-weight concrete over the sunken slabs of bathrooms/ toilets.

Manufactured smooth bends shall be used where conduits change directions. Sharp 90 degrees bends and tees shall not be allowed. Round PVC junction boxes for ceiling points shall have adequate capacity for wires and connectors.

The drawings are schematic and do not generally indicate pull boxes, however, these shall be installed in conduit runs to limit the pulling lengths as required.

Where indicated heavy gauge (1.6mm minimum wall thickness) steel conduit, minimum 20mm dia. Protected with two coats of red oxide anti-corrosion primer and two coats of black enamel inside and outside shall be used for wiring. All conduit accessories shall also be treated as above.

Where required hot-dip galvanized steel conduit minimum 20mm dia. shall be used for wiring. All accessories shall also be galvanized.

Final connection to motors and other equipment shall be in flexible steel conduit encased in weather-proof plastic or good quality PVC weather proof plastic flexible conduit.

18. OUTLET BOXES, PULL BOXES ETC

The outlet boxes for installing switches, sockets, dimmers, etc. shall be of 16 SWG sheet steel de-rusted, degreased, rust-proofed and powder coated. These boxes shall be of suitable dimensions to receive the conduits and the accessories and have ample wiring space. A suitable brass earth terminal shall be provided for connecting the earth continuity conductor in the outlet box. Pull boxes shall generally be of the same specifications as the outlet boxes. All boxes shall have adequate number of knock-outs and have a minimum depth of 50mm.

19. SWITCHES, SOCKETS, CEILING ROSES ETC

These shall be of white molded plastic / metallic suitable for flush mounting in sheet steel outlet boxes. Lighting switches shall be single pole rated for 10 Amps. 250 volts A/C. The switches shall operate with snap action. 3-Pin switch socket outlets shall be rated for 15 amps, 250 volts A/C. Ceiling roses shall be suitable for 5 amps. 250 volts and shall have white plastic molded base plate with copper terminals. The cover of the ceiling rose shall have a suitable cable inlet hole. All other outlets (Computer, telephone etc.) Shall have face plates that match the design of the face plates of switches and sockets. All external switches, sockets and accessories shall be of heavy duty, cast construction, weatherproof type. 5 Amps socket outlets shall be of 3-pin type with integral switch. Power outlets for computers shall be 13A, 250V switch socket 3-Pin with flat terminals. 16A, 2-Pin + Earth Shuko socket outlets to DIN standards shall be provided as required 20A grid switches shall be used, where required.

All outdoor switches and sockets shall be of the weather proof type.

20. UNDER FLOOR BOXES

The under floor pull boxes for power, data and telephone cables shall be of galvanized sheet steel construction (minimum 16 SWG thickness). The boxes shall be installed in floor screed. The height of the boxes shall be between 65mm to 70mm or as required. Suitable arrangement of knock outs for conduit and trunking entry into the boxes is to be provided.

Metal adaptors forming barriers / crossovers / tees, etc. shall be provided within the boxes as required for segregation of power cables from data and telephone cables.

The cover together with the frame is to incorporate vertical adjustment. The cover is to be of minimum 14 SWG thick galvanized sheet steel.

Alternatively the frame and the cover may be of sheet steel de-rusted, degreased, rust proofed and powder coated with the box in the screed remaining of galvanized sheet steel construction. The boxes shall include a brass earth terminal.

21. LIGHTING FIXTURES AND FANS

Lighting fittings & fixtures shall be as specified below, but not limited to it. Specific requirement of each area shall be considered. The determination of quality is based on construction material, shape, finish, operation etc. The Contractor shall submit sample of each lighting fixture designed for the approval of the architect / consultant.

All lighting fixtures shall be suitable for Hospital use as per international standards. All external fixtures shall be IP 54 or IP 65 / 67 as required. The lighting fixtures shall not be the cause of emitting toxic fumes / smokes. Symposium, auditorium and other specific areas shall be provided with special lighting fixtures. Lighting dimmers shall be provided where required.

The lighting fixtures shall be complete with lamps, electronic control gear or ballast as required, radio frequency suppression, power factor improvement up to 0.95, internal wiring with heat resistant wires & suitable connectors.

The housing of lighting fixtures shall be Polycarbonate / PMMA, powder coated sheet steel or aluminum die cast as required. Clean room lighting fixtures shall be provided in all operation theaters (OTs) and other areas as required.

22. LED LUMINAIRE

Luminaire with transparent acrylic cover, housing a high efficiency 8 watts to 120 Watts LED lamp shall be fitted with gasket and accessories for weather and insect proof operation. The light fixture shall be posted on single or double arm pole as shown in drawings. The light fixture should be fully comply with safety norms according to:

- IEC 62471 photo biological safety of lamps and lamp systems including luminaires.
- EN 61347-2-13:2006 ; Safety testing for LEDs.
- EN 60598-1 and EN 60598-2 ; Luminaires safety testing.

22.1 Body Construction

The Road light LED Luminaire shall be as per international standard and made of non-corrosive high pressure molded die cast aluminum housing and Tempered Flat glass with minimal glare. The surface must be finished with powder coating paint. The body should be aerodynamic profiled to give least air resistance. The Luminaire shall be consist of Heat Sink, One-piece cast, low-copper (<0.4% Cu) aluminum alloy. Which shall effectively spread heat to ensure long component life of LEDs and electronic components and provides precise alignment of LEDs and lenses. The Lamp compartment must be IP 66 with lens replaceable possibility.

22.2 Source of Light Output

The light source shall be of white LED type. Single lamp or multiple lamps can be used. View angles of a minimum of 100 or above. The luminous performance of individual LED used should not be less than 50 lumen / watt, when measured luminaire as a whole. The color temperature of white LEDs used in the system should be in the range of 5500oK – 6500o K. Use of LEDs which emit ultraviolet light will not permitted.

The light output from the white LED light source should be constant throughout the duty cycle. The Supplier shall ensure that LED working life shall be >50,000 Hrs. and Color Index (CRI) Ra >75.

The make, model number, country of origin and technical characteristics of white LEDs used in the lighting system must be furnished by the supplier/manufacturer.

22.3 LED Modules

The LED modules utilize aluminum metal-clad board for maximum heat transfer, leading to longer life. The product shall be enabling Pending Aimed Optics, which allows the direction and intensity of the light to be tightly controlled. This control of the LEDs allow fixtures to maintain light levels equal to or greater than that of MH and HPS fixtures at a much lower energy consumption levels.

22.4 LENS

The LED's Lens shall be High impact moulded, UV-stabilized, Profile Acrylic lens, for maximum efficiency of light transmission.

22.5 Led Driver

The LED driver, with high output current accuracy of $\pm 1.5\%$, with a high power factor correction to maximize power utilization shall be required. The driver should comply with UL 1310 / UL48 Class 2 with a built-in over-temperature protection.

22.6 Finish / Colour

Thermally set polyester powder-coated for durability with 3 mils nominal paint thickness and corrosion resistant rated 500 hours salt spray endurance.

22.7 Full Cut Off

The Luminaire should meet IEC standards for full cut off luminaires.

22.8 Emergency Lighting

Emergency lighting fixtures shall be of the self contained 3 hours duration, maintained / non maintained type with Nicd batteries and 8W fluorescent lamp as specified.

Exit sign another legends, which shall be chosen and approved by engineer shall be to BS formats.

22.9 Ceiling Fans

Ceiling fans shall be of capacitor type. They shall be complete with appropriate sized down rod, canopies, mounting brackets dimmer/regulator, blades etc.

22.10 Exhaust Fans/Wall Fans

Exhaust fans shall be wall/window mounted with louvers, shutters, and all fixing accessories.

Wall Fans shall be bracket mounted complete with all mounting accessories.

Degree of Protection to EN 60598

IP 00	Unprotected	Unprotected
IP 11	Foreign bodies > 50mm	Drips angle of occurrence to vertical 0°
IP 20	Foreign bodies > 12mm	Un protected
IP 22	Foreign bodies > 12mm	Drips angle of occurrence to vertical 15°
IP 33	Foreign bodies > 2.5mm	Spray
IP 40	Foreign bodies > 1mm	Unprotected
IP 50	Dust-protected	Unprotected
IP 54	Dust-protected	Splashing water
IP 55	Dust-protected	Jet-proof
IP 65	Dust-proof	Jet-proof

23. CABLE TRUNKING

Cable trunking shall be fabricated from sheet steel having a minimum thickness of 1.6mm and having a galvanized finish, and shall include all covers, accessories, supports, etc.

The trunking shall be of such a design that the lid is secured by mushroom headed screws having threads.

Copper links shall be provided on all the trunking interconnection to ensure that the electrical continuity is maintained throughout the trunking runs.

These copper links are to be fitted on the exterior of the trunking where they are readily visible at all times.

The inside surfaces of all trunking and trunking accessories should be smooth and free from burrs and other defects.

Slotted entries into distribution boards shall be suitably bushed by means of a non-ferrous insulating material securely fixed between the trunking at the distribution boards

Cable retaining clips shall be installed at not greater than 900mm centre within the trunking to prevent damage to cables when the covers are replaced.

Cables within the trunking shall be taped together in groups to denote circuits common to individual pieces of equipment.

The segregation of compartments in trunking shall be maintained at all cross over positions and metal separators shall be fixed to keep the wiring in each compartment completely isolated from the remainder.

The cable capacity of the trunking is to be strictly in accordance with the current edition of the I.E.E. regulations and the stipulated spare space shall be left in all cable trunking.

When trunking passes through a floor, wall, partition or ceiling which constitutes a fire barrier all orifices are to be effectively sealed to restrict the spread of fire.

Generally trunking is to be fixed at not more than 1.8m centre with additional fixing at not more than 150mm on either side of any fitting such as bends and tees. The trunking shall be suspended from structure with steel hangers or supported on walls by angle iron brackets.

24. CABLE TRAY SYSTEM

24.1 General

The tray shall generally be routed under the ceiling slabs and only above the false ceiling. The contractor shall supply all labor material and accessories for the completion of this installation strictly in accordance with the specification laid as under, illustrated in drawings and shown in the schedule / bills of quantities.

24.2 Design

Standard perforation shall be provided in cable trays at both axis i.e.: horizontal & vertical. The cable tray system shall be designed in the standardized modular system and comprise of basic modules of tray, fittings and accessories. Each modular shall be fabricated from prime quality mild steel sheet and then hot dip galvanized of 60 microns. Modular of 90° elbows, T joints and double, T joints shall be used for horizontal changes in the direction of cable runs while hinged connections shall be used for vertical branch off. The branch off joints should be such as to allow for angle connection to be easily bolted to them by means of bottom head screw. End plates shall used to closed off unevenly cut faces of the cable trays and protect the cables from damage. Where required barriers shall be used to permit power cables and cables and cable of all modules shall be subject to the prior approval of the engineer before mass production is taken hand. The cable tray shall have standard lengths of 2440 mm.

The following standards shall be used:

Cable tray width up to 300mm – thickness of metal sheet 1.2 (18SWG)
Cable tray width up to 600mm – thickness of metal sheet 1.6 (16SWG)
Cable tray width up to 900mm – thickness of metal sheet 2.0 (14SWG)

24.3 Technical Specifications

Applicable codes and standards

Latest edition of codes and standards of International Electromechanical Commission (IEC), British Standards Institution (BSI), NEMA, ASTM, ISO and National Fire Protection Association (NFPA) shall be applicable. Where applicable equipment shall also conform to the requirements of Pakistan Standards Institution (PSI).

Other standards are acceptable provided they meet or exceed the quality and requirements of the stated standard and provided the two complete copies in English Language to the purchaser for approval.

IEC	International Electromechanical Commission
BSI	British Standards Institution
VDE	Verein Band Deutsche Elektrotechniker
DIN	Deutsche Institution fuer Normung
JIS	Japanese Industrial Standards
NFPA	National Fire Protection Association
UL	Underwriter's Laboratories
ANSI	American National Standards Institution
ASTM	American Society for Testing and Materials
IEEE	Institute of Electrical and Electronic Engineers
CENELEC	European Committee for Electro technical Standardization
ISO	International Standardization Organization

24.4 Characteristic of Material

Deflection Test:

The vertical deflection of the tray shall be measured at two points along the line midway between the supports and at right angles to the longitudinal axis of the tray.

The two points of measurements shall be at the midpoint of the span of each side rail.

Resistance test procedure

Each specimen should be joined together, using the mechanical connector and following the instructions provided by the manufacturer.

A current 30 amperes, shall be passed through the specimen and the resistance measured between two points 6" on each side of the joint. The net resistance of the joint shall be not more than 0.00033 ohm as computed from the measured voltage drop and the current passing through the specimen.

24.5 Cable Tray Construction

The interiors of all types of cable shall be smooth and free of any projection that might injure cable sheaths and jackets (NEC 318 – 4). All plates should be installed on the outside surface of the supports. Round head bolts, screws or other fasteners (head inside) are to be used exclusively.

The anchoring of cable trays through bottom sections with bolts or screws upon which cables may rest is prohibited. Sheaths or outer covers of cables are subject to damage where the cables are lying on bolt or screw heads. Bolting is satisfactory where the heads of bolts or screws are below the cable supporting surfaces.

Bends in cable trays shall be made with manufacturer's fittings or equivalent. Mitered vertical bends are permitted on ladder cable supports only. The effective radius must be not less than that allowable for the cables involved. Mitered cuts must be positioned midway between rungs

and shall permit not over a 22½° degree directional change per miter or rung. Bends, ells tees and other fittings elbows are available with several radii. The radii of fittings both vertical and horizontal should be suitable to accommodate cables so that they will never bend, either during installation or in the final arrangement, to lesser radii.

All the components of the supply, without exception, from one system and during the erection all the components will match each other without interferences.

24.6 Material

All material in the scope of supply shall be manufactured of prime quality mild steel sheet and then hot dip galvanized after fabrication of 60 microns, including all accessories or prime quality ms sheet and then powder coated including all accessories, as required.

It is manufacture's responsibility that the materials quoted are fully resistant the influence of the chemical product and environment.

For that reason manufacture is requested give alternatives, in case the material mentioned on this document is technically and or / economically not the best solution.

24.7 Installation

The Contractor shall supply and install all cable trays with covers, accessories, supports and fixing. All cables in any one layer are to be run in flat formation on the cable tray. Cable saddles for securing the cables shall be confined to within the width of the tray and all cable saddle fixing shall be accessible from the front of the cable tray. Cable trays shall have return flange edges. All cable trays shall be spaced a minimum of distance of 20mm from any surface upon which they are run. All purpose made saddles supporting the cable tray must be supplied by the Contractor and must be painted with one coat of red oxide before erection.

The Contractor is to ensure that no sagging of the tray occurs. If this is apparent additional supports must be inserted to prevent the cable tray from sagging and to present a neat and workmanlike appearance.

Horizontal runs are to be hung from the ceiling with GI rods and supported on GI channels of appropriate sizes.

24.8 Testing & commissioning

The inspection & testing shall be carried out at the manufacture's work in accordance with the relevant sections of the specification and witnessed by the purchaser prior to the shipment. Or a sample of the required specimen should be submitted for the approvals prior to manufacturing.

25. L.V. SWITCHGEAR

25.1 Main, sub main distribution boards

Specification and other information as mentioned in drawings are applicable.

Main, Sub main Distribution Boards and MCB DBs shall be of the totally enclosed type, dust proof, damp proof and be suitable for floor/surface/flush mounting, and comply with IEC 157, IEC 158, IEC 439, BS 4752. But not limited to them.

They shall be suitable for 400/230 volts 3 phase, 4 wires, 50 Hz system and shall have all components rated for insulation class 600 volts minimum.

All main, sub main and MCB distribution boards shall be factory assembled. Main and Sub-main distribution boards shall be fabricated with 14SWG or as required and MCB DBs with fire protective enclosures having followings specification.

- a) Level of interior fire protection, fire resistance duration of at least 30/90 min. testing of the fire protection enclosures has been carried out in accordance with DIN 4102 Part 11. The electro-technical distribution panel system has been tested in accordance with DIN EN 60439-1 (VDE 0660-500), Section 8.2.1; verification of temperature-rise limits under normal service conditions.

- b) Level of exterior fire protection, fire resistance duration of at least 30/90 min. testing of the fire protection enclosures has been carried out in accordance with DIN 4102 Part 12. The electro-technical distribution panel system has been tested in accordance with DIN EN 60439-1 (VDE 0660-500) section 8.2.1; verification of temperature-rise limits under normal service conditions.
- c) Fire stop cable entry for cable bundles or single cable entry from top and bottom as standard.
- d) Use Silicone seal to increase the degree of protection to IP54, each cable needs to be circumferentially sealed with silicone sealer, and the external fan unit is required.
- e) Enclosure painted with two base coats of anti-corrosive paint and painted with two coats of heavy enamel paint in approved colour or powder coated.

All distribution boards shall be complete with adequately rated copper phase, neutral and earth busbars and be complete with incoming and outgoing cable terminations arrangement, terminal block/line up terminals and shall be suitable for flush mounting of all instruments. The cabling inside the panels shall be suitably numbered and harnessed by means of straps or cords. All distribution boards shall have electrolytic tinned copper busbars.

Cable entries shall be through removable gland plates.

All components shall be installed on mounting brackets inside the enclosure and protected from the front with screwed sheet steel safety plate. The enclosure shall be provided with rubber gasketing and a lockable hinged door with cam fastener. All distribution boards shall be front access type.

The front side of the distribution boards shall be provided with a name plate designating the board. The inside of the door shall have a chart clearly indicating the circuits with their designations. The door is to be grounded by flexible copper cable. This also applies to the common and front plate.

Suitably rated CTs shall be provided as required CTs shall be of class 0.5 for metering and 1.5 for protection.

25.2 Miniature Circuit Breakers (MCB) / Molded Case Circuit Breakers (MCCB)

Miniature circuit breakers (m.c.b's) and moulded case circuit breakers (MCCBs) shall be of the moulded pattern and their switching levers shall be such that they are accessible through the safety plate for operation. The short circuit rating of the circuit breakers shall be as indicated on the drawing. They shall comply to IEC Standards 947-2 and 898, at 230 / 400v – 50Hz.

25.3 Air Circuit Breakers (ACB)

The air circuit breakers shall comply to IEC standards 947 – 2 and shall be fully tropicalized. Main contacts are to easily accessible with wear indication features. The operating mechanism shall be of the stored energy type which can be charged either manually or electrically. The auxiliaries shall be front access able and adjustment free.

25.4 Load Break Switches

Load Break Switches and contractors shall be of AC3 type for motor loads. Air circuit breakers above 630A shall be housed in separate cubicles. Aluminum plate shall be provided for cable entry to ACBs/MCCBs cubicles of 630A and above rating.

25.5 Out Door Feeder Pillars

Outdoor feeder pillar shall be housed in weather proof sheet steel cabinets to IP54 or IP65 as applicable, grade fabricated with 14 SWG sheet steel, degusted, degreased, rust-proofed with two coats of anticorrosive paint or powder coated. They shall be floor mounted on concrete bases of required dimensions.

All components of feeder pillars shall be on mounting brackets inside the enclosure. They shall be equipped with adequately rated electrolytic tinned copper phase, neutral and earth busbars and be complete with cable terminations arrangement, terminal block/line up terminals. High quality housing of fiber glass feeder pillars is also acceptable.

Mounting brackets shall be provided in the enclosure.

All feeders pillar to have copper busbars, isolators, breakers and other components as required.

All distribution boards and isolators shall be identified with circuit designations and source of incoming supply. Lighting switches shall also be identified.

Labels for indoor or weather protected areas shall be white-black (or red) wire, laminated plastic with lettering engraved to show the middle layer. Identification and instructions shall be in black lettering. Warning or danger shall be in red.

25.6 Circuit Identification

In addition to cable identification, cable cores shall be positively identified at every terminal point, in accordance with the drawings.

The cores of non-flexible cable shall be identified in accordance with the "IEE Wiring Regulations" with the addition of polarity markings for d.c circuits.

Ferrules used for identification shall be of interlocking permanently engraved type, designed to encircle the core completely. Markers of the adhesive type will not be permitted. Ferrules shall be correctly sized. There shall be OT improvisation and engravings must not be altered.

Core markings shall be strictly in accordance with the drawings.

25.7 Fuses

All fuses shall be totally sealed, HRC, complying fully with relevant US NEC, IEC & BS codes. Where fuses are employed to provide back up protection to molded case circuit breaker, their rating and fusing factor shall correspond to fault level applicable at particular point. All fuses shall be fitted with a device to indicate operation of the fuse.

25.8 Current Transformers

The current transformers shall be suitable for the ratings specified and comply with the requirement of relevant US NEC, BS and IEC codes. The current transformers including primary winding conductors shall have a short time current rating and duration not less than the short circuit level of the associated switchgear.

The out put of each current transformers shall not be less than the specified output and the tendered shall ensure that the capacity is adequate for the operation of the associated protective windings of each current transformer shall be earthed at one point on; Y.

Magnetization and core loss curves shall be provided for each type and rating of current transformer shall be designed for 5 amperes.

The current transformer shall comply with accuracy classes for power station measurements.

25.9 Protective Relays

Protective equipment shall be designed to disconnected faulty circuits with speed and certainty, without interference with healthy circuits. Relays shall be housed in rugged steel cases with dust tight removable covers. Relays shall be so arranged that replacements can be effected quickly and the minimum amount of labor. Removal of any relay chassis from its cases shall automatically short circuit the respective current transformers secondary winding. Relay shall conform to relevant US NEC, IEC and BS code standards. All relays shall be supplied with the appropriate test terminals to permit testing of the relay without removing from its respective locations.

25.10 Alternator Protection Relays

Following relays are included for the alternator protection;

i. Over Relay / Earth Fault Relay

The over current / earth fault shall be of inverse definite minimum time characteristics. The over load setting to be provided to cover the area beyond the differential zone and up to busbars against earth.

ii. Differential Relay

The relay shall detect all type of fault within the protected zone defined by the current transformers.

iii. Reverse Power Relays

The relay shall consist of a sensitive directional unit. This relay protects the alternator against overheating when the alternator operates as a motor.

iv. Over voltage Relay

This relay is intended to give sensitive protection against over voltage and shall consist of an over voltage element.

v. Unbalanced Load Relay

The relay is intended to prevent unbalancing of load on alternator.

All air circuit breakers and switches are to be provided with appropriate sizes of copper lugs for outgoing feeders. Provision has also to be made for connection of outgoing bus duct, if any.

26. POWER FACTOR IMPROVEMENT PLANT

26.1 General

The power factor improvement plant shall be indoor type, free standing, floor mounted, sheet steel clad with fire protective resistance duration of 30/90 min (internal & external), totally enclosed, completely dust proof, fabricated, mechanically ventilated with vermin proof louvers, supplied fully assembled, readily wired. The plant shall be designed to house all necessary components i.e. p.f. meter, sensing relay, main & auxiliary magnetic contactors, auto / manual switch, on / off push buttons, LED indication lights, main fuses & control fuses / circuit breakers, terminals etc. in dust proof enclosures. Separate cubicle shall be used for housing capacitors, making entire unit in two cubicles.

The fabricated plant housing shall be completely cleaned, degreased and de-rusted and use of antirust primer before apply powder coated paint.

The plant shall be designed to meet service condition at site and provide assurance of performance in mechanical & electrical adjustments. The plant shall be suitable for use on 400V, 50Hz, 3 phase 4 wire A/C supply.

1. Components

- a. The plant shall use dry type static capacitors. These capacitors shall have ratings in as mentioned in the drawing(s) and shall conform to BS 1650 / latest. Full capacitance of plant as specified shall be capable of being switched in steps as number of capacitors units. The capacitors shall be rated at 460V - 3 ϕ – 50Hz.
- b. A minimum of 12 stage sensing relay shall be provided with following main features: -
 - i. **Digital 12 steps with alarms**
 - With built in power Analyzer
 - With continuous Digital power Factor & capacitor Steps Display
 - With automatic search of C/K values
 - Automatic CT polarity adjustment and Automatic Phase Rotation polarity adjustment.

ii. Measurement and Display

- Power Factor
 - Connection Steps
 - Switching Counter and duty cycles
 - Current
 - Voltage
 - KVA
 - KW
 - KVAR
 - Panel Temperature (built-in temperature probe)
 - Total voltage Harmonic Distortion: THD (U)
 - Alarm Log
- c. A manual control switch shall be provided to carry out manual switching of capacitors, if and when required.
- d. Magnetic contactors shall be suitable for 380/420V (AC – 1) operation and provided in sufficient numbers to carry out automatic switching operation.
- e. The distribution bus bars shall be suitable for 800 Amp capacity.
- f. Suitable discharge resistors and hoods shall be provided.

2. Testing

The capacitors shall be charged by application of full voltage for a period of one minute and then discharged through resistors. This will constitute one cycle and the tests shall be carried out for 5 such cycles.

The sensing relay shall be tested in accordance with tests specified in BS 142 / latest.

All small wiring shall be subject to high voltage test at 2000V for one minute.

The plant as a whole shall be tested by application of inductive load.

The consultant may require to witness all or any test(s) at manufacturer's works and the contractor shall cause such tests to be performed without any extra cost to owner.

3. Installation

The PFI plant shall be installed at site in coordination with other works.

The installation of the plant shall be completed with control & power cables, complete in all respect, to the satisfaction of consultants.

27. LV CABLES AND WIRES

In general LV cables and wires shall be with stranded copper conductors PVC insulated, PVC sheathed/unsheathed, single/multicore, armored/unarmored. For lighting and socket outlet circuits they shall be 450/750 volts grades to BS 6004.

All power cables for main, sub-main feeders and power equipment etc. shall be of 600/1000 volts grade to BS-6346 Phase, neutral and grounding conductors shall be color coded red/yellow/blue, black and green. Each circuit shall have its own neutral and grounding conductor. The looping-in system shall be used throughout the installation. Any joint in wires is not permitted.

Final connection to lighting fixtures from ceiling rose/outlet box shall be made with 3 core 1.0 sq.mm PVC/PVC cable in flexible PVC conduit. Copper lugs shall be used for termination of cables. All multicore cables shall be provided with glands of suitable size at entry to the panels.

Power cables shall be clipped to the surface by means of heavy duty spacer saddles and clamps. The saddles and clamps shall be made of cast-iron or steel. Alternatively power cables shall be installed on cable trays or in cable trunking including all installation materials and fixing accessories as specified. All installation materials and fixing accessories such as glands, lugs,

saddles, clamps, brackets etc. shall be provided without any additional cost.

Cables installed in under floor trenches shall be laid in single tier when laid on the bed of the trench. Cables may also be clamped on the walls of the trench by means of heavy duty spacer saddles and clamps of insulated material or fixed on brackets grouted into the side of the trench at a maximum of 600mm intervals. The centre to centre distance between cables shall be equal to twice the diameter of the cable. Cable terminations and joints shall be as per manufacturer's recommendations. Conductor connections and terminations shall be made with compression ferrules and lugs. Cable entry into panels shall be made with brass cable glands. Cable terminal lugs/ wire pins shall be of the mechanical compression type, soldered type lugs shall not be used.

The routing and general arrangement of all cables i.e. power, instrumentation, voice and data should be planned concurrently with main pipe racks and wheel access ways etc. to provide unimpeded direct routes wherever possible. Power cable shall be segregated from instrumentation, voice and data cables to eliminate any possibility of electrical interference with voice, data/ control circuitry.

Cable shall be run in continuous unbroken lengths and joints will not be permitted. Unless the route length exceeds the maximum manufactured drum length, or there is specific authorization for jointing of the cable by consultant/construction manager/ owner.

Each cable shall be subjected to an insulation resistance and continuity test after installation and prior to final dressing in to position and termination. Results shall be recorded and approved by consultant/ construction manager/ owner.

All cables including lighting and small power sub-circuits shall be identified and tagged at each end adjacent to their termination point with approved markers on carrier strip. In addition, all underground cables shall be fitted with non-corrodible identification bands at all points where they enter or leave the area, cable ducts, trench ducts or similar. Lighting and power sub-circuits cable shall be identified at each luminaries/ socket outlet.

Underground cables shall be run in uPVC pipe laid in trenches with back fill. Concrete cable route markers or flag shall be provided at every 20 meter interval and at change of direction.

All jointing and termination work shall be carried out by practicing, fully trained tradesmen, qualified in such a work for the operating voltage concerned.

Brass glands shall be used which are of the thread fixing, hexagon bodied displacement seal type or equal. They shall be compatible with associated cable and maintain the degree of protection of the equipment enclosure. All glands shall be fitted with PVC or PVC shrouds.

The entire body of the cable must enter the gland. The cable shall be on a straight axis from a point at least six diameter before entering the gland. Seals shall be checked for correct size at the point of application.

Care shall be taken to ensure that creepage and clearance distances are maintained e.g. no washers or loose stands.

In addition to cable identification cable cores shall be positively identified at every terminal point.

Ferrules used for identification shall be of the interlocking permanently engraved type, designed to encircle the core completely. Markers of the adhesive type will not be permitted. Ferrules shall be correctly sized. There shall be no improvisation and engravings must not be altered.

APPLICABLE BS CODES

PVC insulated non sheathed wires and cables for domestic application BS 6004 - 1984

PVC insulated and PVC sheathed multicore and flat twin cables and cords wires and cables BS 6004 - 1984

PVC insulated and PVC sheathed and flexible cords BS 6500 – 1975

PVC insulated and PVC sheathed armored and unarmored low voltage cables BS 6346 – 1987.

PVC insulated and PVC sheathed armored and unarmored auxiliary cables (control cables) stranded BS 6346 – 1987 and IEC 502 – 1983

PVC insulated and PV C sheathed single or multicore low voltage power cables BS5467 – 1997 and IEC 502 – 1983

Control cables (auxiliary cables up to 61 cores in solid conductors, armored or armored BS 6346 – 1987

COPPER EARTH CONTINUITY CONDUCTORS (E.C.C)

Area of largest Circuit conduct		Area of earth continuity conductor
1.0 mm ²	-----	1.0 mm ²
1.5 mm ²	-----	1.0 mm ²
2.5 mm ²	-----	1.0 mm ²
4.0 mm ²	-----	2.5 mm ²
6.0 mm ²	-----	2.5 mm ²
10.0 mm ²	-----	6.0 mm ²
16.0 mm ²	-----	6.0 mm ²
25.0 mm ²	-----	16.0 mm ²
35.0 mm ²	-----	16.0 mm ²
50.0 mm ²	-----	16.0 mm ²
70.0 mm ²	-----	50.0 mm ²
95.0 mm ²	-----	50.0 mm ²
120.0 mm ²	-----	50.0 mm ²
150.0 mm ²	-----	50.0 mm ²
185.0 mm ²	-----	70.0 mm ²
240.0 mm ²	-----	70.0 mm ² (Min)
300.0 mm ²	-----	70.0 mm ² (Min)
400.0 mm ²	-----	70.0 mm ² (Min)
500.0 mm ²	-----	70.0 mm ² (Min)
630.0 mm ²	-----	70.0 mm ² (Min)

27 COMPACT (SANDWICH) BUSBAR TRUNKING (BUSWAY)

27.1 General

- The contractor shall supply and install the bus feeders and/or bus risers as a complete system at the locations as shown on the drawings.
- The contractor shall be responsible for routing the busway to co-ordinate with other services. Final measurements shall be made by the contractor prior to release the busway for fabrication.
- Busway shall be 1000V rated insulation voltage. System should be suitable for operation on a 415V/50Hz supply. Conductors configuration can be selected as per design as ;
 - (4W-3P+%100N+%50PE as Housing) as 3-phase 4wire with 100% neutral and 50% PE as Housing, or
 - (4,5W-3P+%100N+%50PE copper/aluminum conductor + Housing) 3-phase 4-,5wire with 100% neutral and 50% PE as a separate conductor and Housing.
 - (5W-3P+%100N+%100PE copper/aluminum conductor + Housing) 3-phase 5wire with 100% neutral and 100% PE as a separate conductor and Housing.
- Each Busbar trunking rating shall be manufactured in same factory premises with all accessories and all manufactured ratings should be tested and certified for same factory's products.
- Those products are type tested individually and comply with IEC 60439-2 standards for 12 type tests and shall be certified by independent authorized testing laboratory (like KEMA-

Nederland) . The following 12 type tests should be performed and certificates obtained in last 2-3 years shall be presented for the approval of Engineer along with the technical proposal.

- Temperature rise limits
 - Dielectric properties
 - Short circuit strength
 - Effectiveness of protective circuit
 - Clearance and creep age distance
 - Mechanical operation
 - Degree of protection
 - Electrical characteristics
 - Structural strength
 - Crushing resistance
 - Resistance of insulating material to abnormal heat
 - Flame propagation test
- f) The entire busway assembly shall be designed and manufactured to withstand short circuit current in accordance with IEC standard. The minimum short circuit rating of the busway shall be 50kA r.m.s. symmetrical.
- g) All bus way products shall be manufactured in same facility, which is Quality Systems Registered by to ISO 9001 and 14001 Environmental Management system. Recent certificates for this manufacturing premise should be attached.
- h) The busbar trunking system shall be supported throughout the entire length as per manufacturer's recommendation to withstand the mechanical load and abnormal forces created under short-circuit conditions. Horizontal expansion fittings shall be provided at places, where the busbar trunking crosses building expansion joints and every 40m straight length. Vertical expansion joints should be provided at every two rigid supports for thermal expansion, building settlement and earthquake.
- i) Flanges shall be provided at all wall and roof penetrations in finished areas.
- j) External fire barriers as required to maintain the fire rating of the adjacent areas, where the bus riser passes through fire rated walls, floors and openings in both horizontal and vertical runs, shall be provided by the contractor.
- k) The busway to be installed indoor shall be of min IP55 against sprinkler system, fire reel hose system and fire fighter hose pressurized extinguishing system. IP67 should be provided with all accessories for Outdoor application with a suitable canopy on top of busbar run for protection of direct sun and rain.
- l) Indoor feeder, plug-in and bolt-on feeder busways shall be compatible with each other.

27.2 HOUSING

- a) The busway housing shall be constructed of pre galvanized steel or extruded aluminum profile to reduce hysteresis and eddy current losses and shall be provided with a durable protective electro statically deposited epoxy polyester paint finish.
- b) The busway housing shall be of high efficiency compact (sandwiched) design, totally enclosed, non-ventilated, for protection against mechanical damage and dirt accumulation.
- c) The totally enclosed housing shall be manufactured by the busway manufacturer in same premise. Modifications of busway to make it totally enclosed by other than the busway manufacturer shall not be acceptable.

27.3 JOINT

- a) The busway joint shall be of the one-bolt type assembly for each way up to 2000A, which utilises a high strength steel bolt and a pair of large diameter spring steel cupped Belleville washers on conductors to maintain proper pressure over a large contact area.
- b) Access to only one side of the busway shall be required for tightening the joint bolts.

- c) It shall be possible to remove any joint connection assembly to allow electrical isolation or physical removal of a busway length without disturbing adjacent busway lengths.

27.4 BUS BARS

- a) The bus bars shall be fabricated from round edged above 99.95% hard drawn high conductivity (HDHC) copper with %100 conductivity or aluminium conductor. Mill certificate should be submitted for particular project.
- b) All bus bars shall be fully insulated throughout its entire length with min 2 layers of polypropylene sleeve and 2 layers of Class B rated (130oC) polyester film between each conductors. Insulation can also be provided by epoxy coating and polyester film together as second different type of materials in order to have double protection between each conductor. . No single type and layer of insulation materials are acceptable.
- c) On plug-in busway (bus riser) lengths, all insulation shall be notched at the openings to allow plug-in unit mounting. Moulded glass-reinforced polyester and polypropylene shall be added at the joint and plug-in opening areas to provide continuous joint integrity. All insulation materials between conductors and joints should be halogenfree and self extinguished type.
- d) The temperature rise at any point of busway shall not exceed 55oC rise above the ambient temperature as per IEC standards when operating at rated load current.
- e) Both feeder and plug-in busway shall be of sandwich (compact) construction, meaning no air gap shall exist between bus bar, to provide superior voltage drop characteristics even at low power factors.
- f) The three-phase, line to line voltage drop shall not exceed 3% at full connected load on the busbar sytem as per project's design criteria.
- g) Busbar manufacturers should have at least 5years of successful and regular installation experience on projects in same environmental areas with full load operation.
- h) Busbar manufacturers should have a local dealer/supervision team who has experience with same manufacturer.

27.5 PLUG-IN OPENINGS

- a) Plug-in busway for bus riser shall have plug-in openings as per the design requirement in any required level from floor level in millimeter for Tap Off boxes location.
- b) Each phase position of a plug-in opening shall be individually insulated.
- c) It shall be possible to inspect the plug-in opening and bus bars prior to the installation of the plug-in unit.
- d) All the plug-in openings shall be covered for IP55, which cover the openings properly when not in use.

27.6 PLUG-IN UNITS (TAP OFF BOXES)

- a) The plug-in units shall incorporate any type, model and brand of MCCBs of minimum 50kA r.m.s. breaking capacity and of ratings as indicated on the drawings.
- b) The plug-in units shall be interchangeable and suitable for plugging in all sizes of plug-in busway.
- c) Tap Off boxes shall be manufactured by sheet metal 1,5mm and coated by epoxy polyester paint as min IP55.

27.7 PLUG-IN UNIT SAFETY DEVICES

- a) The plug-in unit shall be mechanically and electrically interlocked with the busway housing to prevent installation or removal of plug-in units while the switch is in the ON position, and be equipped with an operating handle which always remain in control of the switching mechanism.
- b) The plug-in enclosures shall make positive earth connection with the ground bus before they make contact with the phase bars.
- c) The plug-in units shall be equipped with internal barriers to prevent accidental contact of fish tape and conductors with live parts on the line the protective device during time of cable terminations.
- d) The door covers of all plug-in units must have interlocks to prevent the cover from being opened when the switch is in the ON position.
- e) All units shall be lockable type with padlock to avoid any service by unauthorized person.

27.8 EXECUTION

- a) Ensure that final installation of busway assembly is fully co-ordinated with aspects of building construction and with the work of other services. Final field measurements shall be made by the contractor prior to release the busways for fabrication.
- b) Install busway, accessories and associated fittings, as indicated on the drawings and in accordance with manufacturer's recommendations and Manual strictly. Supports and hanger spacing shall be noted on layout drawings and shall not exceed manufacturer's recommendations.
- c) Provide curb around interior floor penetrations.
- d) Install busway with integral weather seal located where busway penetrates exterior wall and/or roof. Provide wall and/or roof flange and seal around opening to maintain weather tight installation.
- e) Tightening the joint bolts to the required torque in accordance with manufacturer's recommendation.
- f) Cover the busways with plastic wrappers until the building is clean and busways are ready to be tested and energised.
- g) Megger the busways in presence of The Engineer and report.
- h) All actions from unloading, handling, supporting, installation until testing should be done as per Manufacturer's Manual strictly.

28. EARTHING

The earthing system shall comprise of copper earthing plates of 24" x 24" x 6" thickness buried at a depth of 25 feet or as per site requirement as advised by Consultant, from ground level in a 250 Kg mixture of salt and charcoal. This work includes excavation, perfect back filling and all necessary materials as per drawing and as per standard practice according to the satisfaction of Consultant. Two earthing leads of PVC insulated copper wires of specified size in PVC conduit shall be used to connect the earth plate(s) to the equipment. Piping for watering of earth plates shall be provided. The earth resistance test shall be performed as per the Electrical Inspectors requirements. Earth resistance shall not exceed one ohm for each earthpit. If the required earth resistance is not achieved, additional earthing set shall be provided and connected in parallel until the specified resistance is achieved (without any extra cost).

Concrete Inspection Chamber(s), heavy duty C.I. covers, fixing clamps all accessories etc. are deemed to be included in the Electrical Contract.

29. FIRE ALARM SYSTEM

29.1 Scope of Work

The work under this section consists of supplying, installing, testing and commissioning of fire alarm system as stated herein, as shown on tender drawings and as given in the bill of quantities. All materials shall be new.

29.2 General

All the equipment shall be as NFPA or BS based and designed on BS5839 Part I. The contractor shall furnish with the tender bid, complete details of equipment, materials etc. All products shall be made by one manufacturer and shall be supplied by the authorized sole agent of the manufacturer.

The entire system shall be used according to the NFPA 72 or BS5839 Part 1 1998 Sec 6.6.2 6317 1991 guide lines and latest applicable codes of NFPA and IEC.

The Fire Alarm system shall be intelligent addressable type. It shall consist of manual call points, addressable smoke detectors, addressable heat detectors, addressable sounders, addressable control element line isolators etc. etc. as required, and intelligent addressable fire alarm control panel to be interfaced with building management system (BMS) or with other system of building as required.

The sensors shall provide a means of test whereby they will simulate an alarm condition and report that condition to the FACP, such a test may be initiated at the sensor itself (by activating a magnetic switch) or initiated remotely on command from the FACP.

The sensors shall provide address setting on the sensor's base using decimal switches. Addressable sensors that use binary address setting methods such as a dip switch, code cards or soft addressing are not acceptable. The sensors shall also feature an internal identifying code that the FACP shall use to identify the type of sensor.

29.3 Minimum Applicable standards / Codes

The following standards & codes shall be applicable for the materials covered within the scope of this section:

NFPA 72A	:	Local protective signaling system
NFPA 72E	:	Standards on automatic fire detectors
NFPA 72F	:	Installation, maintenance & use of alarm in communication system.
NFPA 72G	:	Notification appliance for protective signaling system.
NFPA 72H	:	Testing procedure for local protective signaling system.

Each and all items of the Fire Alarm System shall be listed as a product of a single fire alarm system manufacturer under the appropriate category by underwriter laboratories (UL) & shall bear the UL label. Equivalent to British Standards shall also be acceptable.

The material submittal and shop drawings / manual(s) should contain minimum information as mentioned below:

Manuals	:	Submit simultaneously with the drawings, complete operating and maintenance manuals listing the manufacturers' name (s) including technical data sheets.
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29.4 Quality Assurance

The system shall be installed by competent and technicians recommended by the manufacturer of the equipment and approved by consultant so as to provide single source responsibility of complete installation and proper operation of the Fire Alarm System and shall include debugging and proper calibration of each component in the entire system. Further, the supplier shall have an in-place support with technical staff, spare parts inventory and all necessary test and diagnostic equipment with an experience of at least 10 years in the country.

29.5 Material

The intelligent Analogue Addressable Fire Alarm Control Panel (FACP) shall be microprocessor based and have the ability to indicate the exact location of the fire to enable fast response to any fire calls. It shall have flash Rom to provide comprehensive addressing facilities and fully programmable user display using relevant software. Internal facilities shall include:

A charger and rechargeable batteries of adequate AH to provide back for 48 hours for the operation of entire system and 30 minutes for the continuous operation of all sounder.

The principle function of the system shall be surveillance for up to 512 field sensing devices. (sensors on 4 loop Modular design).

A maximum 128 devices may be connected to each loop.

Mains supply shall be 230VAC 50Hz.

The system shall operate on 24V DC.

80 character LCD status display.

Operator commands and system interrogation via keypad.

Digital signaling to detectors with parity error detection.

On-site / PC or Via PC programming of site specific information PC TO PC provided. The software to be up loaded / down loaded as required.

Using software in the FACP the sensors may automatically compensate for dust accumulation and other slow environmental changes that may affect their performance.

A watchdog facility to test microprocessor integrity.

Additional protection circuitry for immunity to transients and EMI.

A 10-zone programmable sounder module and 4-zone relay module, with provision of extendibility in program zones.

Zonal fire indicators (LED's) and zonal fault/test/disabled (LED's) shall be provided. It shall be possible to increase the number of zonal fire and fault/test/disabled LED's simply by "plug-in" extender cards.

Four separate push buttons shall provide control of sound alarms (Evacuate), silence / resound, mute / accept and reset, and shall be located adjacent to the main LED indication as per instruction of Consultant.

User Control Levels: The fire control panel shall have three user control levels.

At all three levels, the LED displays shall indicate the condition of the installation, the zone LED's shall indicate the location of fire alarm or fault and the alphanumeric display shall be provided detailed fire alarm or fault information.

Level -1: All display shall be functional, but the front panel shall be inhibited.

Level-2: All display and all front panel controls shall be functional. Changes to the system configuration shall not be accessible at this level. User level 2 shall be reached by entering a unique 4 digit password from level – 1.

Level-3: All front panel controls shall be functional and full system configuration and programming shall be possible. User level 3 shall be reached by entering a unique 4 digit password from either level-1 or level-2. User level-3 shall be for use by the system installer / maintenance contractor.

A level 2 password shall not allow access to level 3 functions.

Up to 10 level 2 password shall be definable from level -3.

Program integrity option shall display the panel software version along with ROM and RAM checksums. The RAM checksum shall alter whenever the configuration is changed. For Example, the checksum figure shall change when either adding or removing devices or changing text assignments. After the final configuration has been entered the program integrity shall be checked and the RAM checksum figure recorded.

Day Modes: The fire alarm control panel shall have the ability to automatically invoke operating modes according to the time of day. Each mode shall have adjustable start and finish times. Outside of the designated start and finishing times, the panel shall revert to normal operation. The operating modes will consist of:

Delayed mode: During the day or night the alarm signal from the detection points shall be immediately recognized and identified on the panel display, but no outputs switched on until staged timers have expired.

Sensitivity mode: Shall allow smoke and temperature detectors to use different pre-alarm and fire alarm thresholds during day and night mode.

Verification mode: Shall allow smoke detectors to tolerate transient alarms according to the programmed verification delay time during either day or night.

The front panel shall include following controls and display:

Fire, Pre-Alarm and Fault indicators.

Programmable LCD status display with full menu reporting options.

Sounder mute, system reset, buzzer mute, lamp test and evacuate push button controls.

Status indicators for isolate, test, sounder fault, output fault, software fault, power fail and supply healthy.

All controls shall be labeled, all zones locations shall be identified, and the FACP shall be provided with a set of permanently mounted operating instructions, to avoid confusion. Zone location identification shall be as approved by Consultants and contain up to three lines of text with 1/8" minimum character height. It must be possible for the emergency operator to panel specific zone into evacuation manually.

All hardware and software allows the panel configuration and operation to be changed at the panel. It shall be possible to display and circuit on a LCD or LED annunciator located any where on the network.

The panel shall have two serial communication ports. An optional "plug-in" RS485 or RS232 card will support a PC front-end graphics package or peer-to-peer panels network connection In future. An RS485 peripheral bus shall support a further 126 addresses in addition to the detection loops. The panel shall have the ability to operates day, delayed, sensitivity and verification mode, and also store 600 events either diagnostic or normal mode. In case of fire occurs FACP display shall automatically show a telephone No. to call for assistance.

29.6 Addressable Manual Call Points

Addressable manual call points shall be of rugged ABS plastic construction designed for recess, semi-recess or surface mounting on a standard socket outlet box. It shall incorporate all the necessary circuitry to relay its unique identification and position to the analogue control panel. The break glass design shall be with a frangible element. The frangible element shall consist of a glass blank with a thin plastic film laminated to its surface, avoiding injury to the thumb and confining the glass pieces within the all point when operated. The call point should have neon indication to indicate it is "ON" with the system. The word "Fire" shall appears on the front of manual call points. Manual call points should be suitable for semi flush mounted as required.

29.7 Addressable Sounder

The addressable electronic sounder shall provide high efficiency tones and high outputs. It shall be set to provide up to 4 different tones. It shall be designed to operate on very low current rating and shall operate continuously for 2 hours. Operating voltage shall be 9 – 28 volt. It shall be made of ABS plastic case in Red or White color. It shall be small and compact in design and weight. The output shall be 100dB at 1meter. It shall be recess, semi recess or surface mounted on a standard socket outlet box. Self test facility shall allow all sounders to be tested from the control panel by one person.

29.8 Addressable Photoelectric Smoke Detector

Smoke detector shall be housed in an off white self-extinguishing plastic. The base unit shall contain an address circuit, and also a pulse generator to provide coded signals representing the analogue voltage from the sensor. The address for each base unit shall be set to a number from 1 to 100 by an 8 pole switch visible through a hole in the base unit case. The unique address should not have to be changed, and shall remain in position with the fixed base unit. The sensors shall be removed or replaced without resetting the coding switch, preventing accidental location numbering of replaced units. It shall have Red LED (dual preferable) which flash periodically in the quiescent mode and flashes continuously in Fire, Alert or Fault mode. Smoke Detectors shall use photoelectric (light-scattering) principle to measure smoke density and shall on command from the FACP send data to the FACP representing the analogue level of smoke density. The sensor sensitivity shall be adjustable in the field through the field programming of the system.

29.9 Addressable Heat Detector

The addressable Heat Detector shall be constructed of self Extinguishing plastic and protected against moisture and corrosion. Base unit contain an address circuit, and also a pulse generator to provide coded signals representing the analogue voltage from the sensor. The address of each base shall be set to number from 1 to 100 by an 8 pole switch visible through a hole in the base unit case. The unique address shall not have to be changed, and remain in position with the fixed base unit. Sensors shall be removed or replaced without resetting the coding switch and shall have a red LED (dual preferable) which flashes periodically in Quiescent mode and flashes continuously in Fire alert of fault mode. It shall have a sensing unit to detect a change in temperature and incorporate and electronic control circuit. When the ambient temperature changes by a predetermined amount, the sensing unit shall activate and initiate the integral LED. It shall operate on 60C°. Operating voltage shall be 10V to 30V DC. Where mentioned in the drawing(s), rate of rise temperature type Heat Detector(s) shall be used.

29.10 Wiring and Cabling

Wiring and cabling of fire and alarm system shall be carried out as per drawings in PVC conduits shall be used if installed concealed in concrete or 16SWG m.s. conduit for surface installation.

All wires and cables shall be color coded, tagged and checked for open, short or ground faults. No transportation of colors will be permitted. All wiring shall be made on terminal blocks of proper size and type for the services involved. Cable joints shall only be allowed on the detector bases.

29.11 Installation

The installation of fire alarm system equipment shall be in strict accordance with the manufacturer's instruction / recommendations and these specifications.

The testing of fire alarm equipment shall be in compliance with the relevant standards and regulations. During testing of equipment, emphasis shall be laid on the following:

- Operational Safety
- Regular functioning of the system and devices
- Protection against false ceiling

Various detectors like smoke, heat, manual call point etc. shall be subjected to the basic tests and sensitivity tests. The automatic detectors shall be tested in various ways to check real and false alarm behaviors.

29.12 Training

A training session shall be presented a fully qualified, trained representative of the equipment manufacturer / supplier who is thoroughly knowledgeable of the specific installation. The training shall be given to personnel responsible for operation and maintenance of the system.

The training session shall include but not limited to the following:

Detailed explanation of wall charts.

Function of each control switch

Period operational testing of panel / devices.

Maintenance of fire log book supplied by manufacturer.

Actions to be taken upon receiving following signals:

- False alarm indication.
- Trouble on any initiating of indicating zone
- Common alarm or common trouble indication
- Low battery voltage indication.

Field modifiable programming.

SUB-STATION WORKS

A - SCOPE OF WORK

The Electrical Contractor shall supply all labour, materials and equipment necessary for the complete installation, testing and commissioning of the entire electrical works which shall broadly include but not limited to the following as per specifications, drawings and bill of quantities.

- a. 11KV Panels
- b. Power Transformer
- c. H.T Power Cables
- d. Approval from Electric Inspector and **K.E.** for Entire Installations and securing power connection from **K.E.**

1. GENERAL

The entire electrical installation shall be carried out by an approved licensed Electrical Contractor authorized to undertake such works.

All works are to comply with the latest Edition of the IEE Regulations for Electrical Installations UK, the Electricity Act 1910, the Electricity Rules 1937, and in accordance with the requirements of the local inspector, the utility supply authorities (K.E. / Pakistan Telecommunication Corporation), Contract Drawings/specifications, BOQ and to the satisfaction of the Architect/Consultant/Owner.

2. APPROVAL FROM ELECTRICAL INSPECTOR

The Contractor shall be responsible for completing all formalities such as serving notices, submitting drawings / documents and obtaining all permits, sanctions, connections and having the installation passed and commissioned by the relevant authorities and obtain an approval certificate from the concerned Electrical Inspector's Office for the total load of the premises including the load of HVAC machines elevators, pumps etc.. All costs involved in obtaining such permits, sanctions, approvals from the concerned authorities are deemed to be included in the contract price and no extra payment shall be made to the Contractor.

3. STANDARDS AND TYPICAL DESIGNS

The specification either cites or implies British / IEC Standards. Other comparable European and US Standards any typical designs are acceptable, provided that they in no way detract from the quality, safety, operability, or durability of the equipment and material furnished. However, when other standards or typical designs other than those cited or implied are offered by the contractor, he shall set these forth in detail in his proposal.

Samples of all materials / equipment are to be submitted to the Architect / Consultant / Owner for approval before purchase or fabrication / installation.

4. SHOP DRAWINGS

The locations, routings, and installation heights of electrical equipment, conduits cable trays etc. given on the design drawings are approximate. Based on site conditions and in coordination with civil and mechanical drawings the contractor shall prepare shop drawings showing proposed routes of conduits and positions of equipment, including mounting and fixing details and submit the same for approval. Three sets (min.) of drawings and technical literature/ brochures for all the electrical equipment / systems are to be submitted four weeks in advance of the execution of the works and approval obtained before execution of works.

5. CLIMATIC CONDITIONS

Equipment and materials supplied shall withstand under all conditions of continuous operation and without developing any defects, the following environmental conditions.

Maximum temperature	:	50 deg. C
Minimum temperature	:	-15 deg. C
Relative humidity	:	90 %

6. EQUIPMENT PROTECTION

Unless otherwise stated all equipment supplied shall conform as a minimum to the following protection classes:

Indoor	I.P. 40
Outdoor	I.P. 54

7. TESTING AND COMMISSIONING

On completion of the works the following tests shall be performed and a satisfactory performance certificate in respect of each test shall be submitted with the final bill. All equipment/instruments for the tests are to be provided by the Contractor at no extra cost.

- a) Earth Resistance test and earth loop impedance test.
- b) Insulation resistance test of the entire electrical installation between phases, phase to earth and phase to neutral.
- c) Polarity tests on switches, MCB's, fuses, etc.
- d) Other tests as mentioned in the specifications and Operation tests and commissioning of the entire electrical installation including all equipment.

8. MAINTENANCE AND WARRANTY

The Contractor shall be responsible for the entire electrical works and all equipment supplied by him and warranty the same for a period of twelve months from the date of the completion certificate. Any defect due to the workmanship or equipment failure shall be replaced by the Contractor free of charge during that period.

9. AS-BUILT DRAWINGS

On completion of the works the Contractor shall supply one reproducible and three copies of as-built drawings which clearly indicate all amendments, junction boxes, pull boxes, etc. These shall be provided at no extra cost. The as-built drawings shall indicate the entire electrical installation as actually carried out on site including schematic diagrams.

10. SITE CONDITIONS

The Contractor shall visit the site before submitting his quotation and acquaint himself with the site conditions, and check the specifications, design drawings and the bill of quantities.

Omissions/errors, if any, are to be brought to the attention of the Consultant or included in the bid. After award of the contract no claims shall be entertained.

11. OPERATION AND MAINTENANCE MANUALS

The Contractor shall submit four sets of manuals for all the electrical equipment supplied and installed by him which shall include detailed operation and maintenance instructions for each item as recommended by the manufacturer. These manuals shall be submitted on completion of the works.

12. ABBREVIATION FOR STANDARDS

The standards, code of practices, and recommendations of the following societies or institutions have either been used in the specification and or cited here as a general level of quality for equipment, material and workmanship.

Abbreviations for international institutions are given below:

International Electromechanical Commission.	IEC
European Committee for Standardization	CEN
International Standards Organization	ISO

Abbreviations for some European societies and standards institutions are as follows:

Associations Francaise de Normalization	AFN
British Standard Institution	BSI
Deutsches Institute for Normung	DIN
Institutions of Electrical Engineers, London	IEE
Chartered Institutions of Building Services	CIBS

Abbreviations for Pakistani Societies & Standard Institutions:

Water Power Development Authority	WAPA
Pakistan Telecommunications Corporation	PTC
Karachi Electric Supply Corporation	KESC

13. ASSOCIATED CIVIL WORKS

The cost of any civil works, (cutting, chasing, excavation, backfilling, grouting, drilling etc. and making good) associated with any item of the electrical works shall be included in the quoted price for the item. The Contractor shall be responsible for carrying out these civil works and making good and the cost shall be deemed to be included in the quoted price.

The Contractor shall take care not to damage the structure during execution of his work. If so done, he shall repair and make good all losses at his own cost.

B - SPECIFICATIONS FOR POWER TRANSFORMER

- Three Phase power transformer for indoor use having transformation ratio 11000/415 volts at frequency of 50 Hz and KVA ratings as given in the bill of Quantities shall be supplied and installed by the contractor.
- The transformer shall be manufactured, supplied and tested in accordance with **K.E.** requirements and in compliance with relevant BSS and IEC requirements.
- The transformer shall be mineral oil immersed type with core and windings immersed in mineral oil. The core shall be of a laminated construction made of high grade electric steel sheet rigidly backed and free of vibrations due to frequency and stresses.
- The windings shall be uniformly insulated, the thermal class of insulating material shall be Class – A Test voltage shall be based on highest of the system voltage i.e. 12 KV. Power frequency voltage shall be 28 KV and impulse voltage to be 95 KV. The wave being 1/50 micro seconds.
- The insulation to earth of the windings shall be uniform.
- The limits of temperature rise above ambient of the windings, cores and oil shall be as under

Winding	-50 °C
Core	-50 °C
Oil	-45 °C
- The transformer shall be designed and constructed to withstand, without damage, the effects of short circuit of magnitude equal to 25 times of the symmetrical r.m.s. value of value of valid current for 2 seconds.
- The transformer shall be capable of withstanding, without damage on any tapping, under service condition, the electromagnetic forces arising under short circuit condition as determined from the symmetrical peak value of the current in the winding which shall be taken as not greater than 2.55 times the over current derived.
- The transformer shall be capable of withstanding without damage to nay tapping under service condition, the thermal effect of a short circuit at the terminals of any winding for 2 second.
- The transformer shall be provided regulating taps. The adjusting tapping shall be +5% +2½% normal; -2½%, -5% and -7½%. The tapping being located on the higher voltage winding.
- Tap changing shall be affected by means of an externally operated off circuit switch capable of being locked in position. It shall be accessible with safety.

12. When tapings are used to compensate for variation of voltage, the transformer shall be capable of operation at its rated KVA capacity on any tapping without injury. The tap changing gear shall be capable of carrying the same currents due to external short circuits.
13. The method of cooling shall be natural air, the method of circulation of oil shall be by natural thermal head.
14. The primary windings shall be “Delta” connected and the secondary winding shall be “Star” connected internally. The star point shall be brought out as neutral. The internal connections shall be clearly indicated on the nameplate together with tap changing connections. The vector group DY 11 of the transformer shall also be indicated on the nameplate.
15. The transformer tank shall be of welded construction made high grade steel plate. It shall have either a finned external construction or tubular constructions to facilitate the natural air-cooling.
16. The tank shall be tested any leaks by any of the following methods:
 - a) Compressed Air Test
 - b) Oil / Water Pressure test
 - c) Penetrating liquid without pressure.
17. An oil conservator tank fitted with a dehydrating breather and oil level indicator shall be internally fitted to the transformer tank.
18. The complete assemble tank shall be tested to withstand without deformation or leakage a pressure of 15 lbs/sq in (1.05 kg/sq.cm)
19. The tank finish shall be battleship colour. The paint shall be highly resistance to the effects of high temperatures and shall have a long life under the normal working conditions. As a minimum it shall consists of a priming coat and two finish coats applied after compete derusting and degreasing of the tank. The thickness of the paint shall not be less than 0.12mm.
20. The oil level indicator shall be visual glass type with minimum oil level marking at 30 °C and with two additional marks “Empty” and “Full” to be provided. These corresponding to the upper and lower temperatures for which the transformer is required to operate on site.
21. HV / LV bushing for HV/LV Cables, Terminations from Top bottom etc. as per site conditions, shall be provided Arrangement for adequate solidly grounding the natural shall be made.
22. The following routine tests shall be carried out on the transformers in the presence of the Engineer.
 - i) Temperature rise Test
 - ii) Impedance Test
 - iii) Ratio and Phase angle test at one standard load.
 - iv) Dielectric Test of law Frequency.
23. A certified copy of a complete type tests carried out on an identical transformer shall accompany the transformer, failing which the Contractor shall make arrangements to carry out these tests in the presence of Engineer without any extra expenses to the owner.
24. The following fittings shall be provided with each transformer:
 - i) Rating Plate
 - ii) Terminal Marking Plate
 - iii) Lifting Lugs
 - iv) Earthing Terminals for Tank
 - v) Oil filling hole and Plug
 - vi) Oil level indicator
 - vii) Drain valve with built-in sampling device
 - viii) Conservator
 - ix) Air Vent
 - x) Dehydrating Breather
 - xi) Dial type thermometer with maximum temperature indicator

- xii) Double Float Buchholz Relay complete with auxiliary relay on the panel and connections up to 11 KV Panel and Audio Visual Alarm provided. It should be able to trip off the 11KV panel in case of overheating & other malfunction of transformer.
- xiii) Steel Rollers with rolling direction parallel to the longer side.

25. The rating plate shall carry the following information's

- i) Manufacturer's Name
- ii) Manufacturer's Serial Number
- iii) Year of Manufacture
- iv) Owner's Identification Mark
- v) Rate KVA
- vi) No of Phases
- vii) Frequency
- viii) Rated Voltage at no load (Higher / Lower Voltage)
- ix) Percent Impedance Voltage
- x) Rated current (Higher / Lower Voltage)
- xi) Winding connections and phase displacement symbol of vector diagram
- xii) Type of cooling
- xiii) Total weight of the transformer
- xiv) Total quantities and weight of the oil
- xv) Weight of core and winding assembly

26. The terminal marking plate shall carry the following information:

- i) Vector Group Symbol
- ii) Winding connection of high voltage and low voltage sides
- iii) Tapping with subscripts
- iv) Voltage ratios at various tapings the lower voltage being kept constant
- v) Rated current (Higher / Lower Voltage)

Letters ABC shall be used for the high voltage side and abc shall be used for low voltage side.

27. The transformers of the ratings as given in the Bill of Materials shall be supplied, tested, installed & commissioned under this contract and shall be completed in every respect with first fillings of dehydrated mineral oil complying **K.E.** requirements.

C - SPECIFICATIONS FOR INDOOR 11KV VACUUM CIRCUIT BREAKER

1. SCOPE

This specification covers 11KV, triple pole, metal-clad, vacuum withdraw able type circuit breaker for indoor installation. The circuit breaker shall be designed and built to give highly sufficient and reliable service under climatic conditions described herein.

This specification is general based on IEC Publication Nos. 56, 298 and 694.

This specification is meant for 11kv Metering and Protection panel. 11 kv isolator shall be without metering and protection.

2. MAIN MV PANELS

The MV switch panel shall be metal clad fabricated from 14 SWG sheet steel cubical type, totally enclosed, and vermin proof floor mounted free standing de-rusted, degreased prime with two coats of zinc chromate and painted with two coats spray of color RAL 7032 and two coats of Epoxy based paint, protection class IP40 in a drawn out trolley. All control wiring and the terminals shall be provided with numbered ferrules. It should be completed in all respect with material and accessories, factory assembled, tested and finished according to the specifications and to the normal requirements (meeting with sea side conditions).

The MV panel shall be for front operation and suitable for coupling of additional units on either side, in future and should have the adequate clearance from live parts to avoid flash over by switching surges, vermin, pests etc. and should have anti condensate heater to avoid condensation in side the panel.

The MV switch panel so provided shall be strictly following the standards including K.E. standards as applicable given below:

IEC 60056	Vacuum Circuit Breaker
IEC 60298	Panel Cubical
IEC 185	High Voltage CTS
IEC 180 & BS 3941	Potential Transformer

For panels without metering, treat the following clauses deleted or replaced:

- a) Clause 5.14.1(b)
- b) Clauses 5.14.3 and 5.14.4
- c) In clause 5.14.2, replace double wound CTs with single wound having only one secondary winding of Protection class 5P20.

3. SYSTEM AND CLIMATIC CONDITIONS

3.1 System Conditions

- a. Nominal system voltage 11kv
- b. Highest system voltage 12kv
- c. Highest system voltage for equipment 15kv
- d. Phases 3
- e. Frequency 50kv
- f. Lightning impose withstand voltage (BIL) 95kv
- g. System earthing:
Star-Star Power Transformer at grids with neutral in 11KV earthed through resistance for limiting the fault current to 1.5 kA.

3.2 Climatic Conditions

- a. Maximum ambient air temperature 50°C
- b. Maximum daily average temperature 40°C
- c. Minimum ambient air temperature -15°C
- d. Maximum relative humidity 90%
- e. Attitude: Sea level
- f. Location: Sea Coast (interior is semi-desert)
- g. Pollution: Severe marine pollution on account of wind blown sand and dust with salt content and salt laden spray and mist.

4. TECHNICAL DATA

4.1 Circuit Breaker

- a. Breaking Capacity 350 MVA
- b. Nominal System Voltage 11 KV
- c. Highest System Voltage 12 KV
- d. Highest System Voltage for equipment 15 KV
- e. Rated Current 630 A
- f. Phases Three
- g. Frequency 50 Hz
- h. Righted lightning impose voltage (BIL) 95 KV
- i. Rated one minute power frequency withstand voltage 28 KV
- j. Rated peak withstand current 45 KA
- k. Rated short circuit breaking current (1 See) 18 KA
- l. Rated short circuit making current 45 KA

4.2 Earthing Switch

- a. Rated voltage 11 KV
- b. Rated insulation level
 - i. Rated one minute power frequency withstand voltage 28 KV
 - ii. Rated lightning impose withstand voltage
 - To earth and between poles 95 KV
 - Across the isolating distance 105 KV (Peak)

c.	Rated frequency	50 Hz
d.	Rated short time withstand current	18 KA
e.	Rated duration of short circuit	1 Sec
f.	Rated peak withstand current	45 KA
g.	Rated short circuit making current	45 KA
h.	Temperature rise	As per IEC-129

5. DESIGN, CONSTRUCTION AND MATERIAL REQUIREMENT

5.1 Applications standards

The circuit breaker including its operating devices and auxiliary equipments shall be designed, manufactured and tested in accordance with the following IEC publications as amended or notified to date.

PUBLICATION T I T L E

IEC-56	High voltage alternating current circuit breaker.
IEC-298	A.C. Metal-enclosed switch gear and controlgear for rated voltage above 1KV and upto and including 52 KV.
IEC-694	Common clauses for high voltage switchgear and controlgear standards.
IEC-265-1	High voltage switches
IEC-51 (Parts 1,2,3,5 and 8)	Measuring Instruments
IEC-185	Current Transformer
IEC186	Voltage Transformer
IEC-1036	Alternating current static watt-hour meters for active energy (Classes 1 and 2).

In case, requirements laid down herein differ from those given in the above stated standards in any particular component, the circuit breaker shall comply with the requirements laid herein.

5.2 **Construction and Operating Mechanism**

- 5.2.1 The circuit breaker and all the accessories shall be so designed and constructed as to comply with the requirements set out in this specification.
- 5.2.2 The switchgear shall be supplied in the form of a single panel. Each panel shall comprise of a vacuum circuit breaker and all its associated equipment and shall be contained and self-supporting.
- 5.2.3 The circuit breaker shall be triple pole and all the three poles shall be coupled so as to operate simultaneously. The circuit breaker shall be draw-out type mounted on a trolley suitable for indoor installation.
- 5.2.4 The operating mechanism of the circuit breaker shall be designed to ensure safety during operation, inspection, cleaning and maintenance and shall be so arranged as to minimize the risk of fire arising and spreading.
- 5.2.5 The operating mechanism shall be manually charged spring type with push buttons for opening and closing the breaker. The closing mechanism shall be independent of the operator's efforts and shall consist of springs charged in readiness for closing operation. The closing spring shall be capable of manual charging. Spring charged and spring discharged indicators to be provided.
- 5.2.6 The circuit breaker shall be manually operated by a quick make mechanism. The operation shall be in one step and the mechanism shall not hold in a intermediate position in any case. The fixed as well as moving contacts shall work in vacuum in such a way that the are produced during making or breaking operation is quenched in a satisfactory manner.
- 5.2.7 The operating mechanism and stored energy shall allow the following sequence:
0-3 min – CO-3 min-CO

- 5.2.8 The operating handle when made of metal shall be earthed and insulated from the operating shaft for the full insulation withstand voltage.
- 5.2.9 Where necessary, parts of mechanism shall utilize materials such as stainless steel, brass or gunmetal to prevent sticking of these due to rust or corrosion. The design shall be such to eliminate the risk of inadvertent operation due to fault currents, stresses, vibration or other causes.
- 5.2.10 All removable components of the same type and rating in a given assembly shall be interchangeable with those in others.
- 5.2.11 The breaker shall be equipped with operation counter meter.
- 5.2.12 The contact burnt-out should be indicated visually.
- 5.2.13 The overall design of the mechanism should be such as to reduce mechanical shock to a minimum and shall prevent inadvertent operation due to fault current stresses, vibration or other causes. Means should be provided to prevent operation of the mechanism when maintenance work is in progress.

5.3 Busbars

- 5.3.1 The circuit breaker shall have a set of three 99% IACS electrical conductivity round edge copper busbars of adequate size. The busbars in the circuit breaker shall be suitable for extension on both sides into adjoining breakers or isolators directly (without adapter panel).
- 5.3.2 The busbars shall be completely covered with insulation material capable of withstanding twice the rated voltage. The material shall ensure full adherence to the busbars. Snap or PVC covering however, is accepted at the joints. The insulating material of sleeves and covers shall have fire resistant properties.
- 5.3.3 The temperature rise of bus bars and their joints shall not exceed 40°C, during testing for short circuit breaker.

5.4 Support Insulators

- 5.4.1 The Busbars shall be supported by porcelain bush / epoxy resin type insulators. The insulators shall be made of high quality porcelain material by the wet process. The entire insulator shall be smoothly glazed and shall be free from imperfections of all sorts. The electrical characteristics shall also be suitable for highly polluted atmosphere as mentioned in clause 2.2. The cast resin insulators of equivalent characteristic can also be considered. Some of the characteristics of support insulators are given below:
 - a. Creepage distance – 250 mm
 - b. Dry arcing distance – 170 mm
 - c. One minute power frequency withstand voltage 28 KV.
 - d. Lightning impulse withstand voltage (BIL)-75 KV.
- 5.4.2 The busbars and support insulators shall withstand the forces produced by rated short circuit current as mentioned in clause 3.1

5.5 Safety and Interlocking

- 5.5.1 Safety shutters shall be provided which shall automatically cover the orifices to live parts, when the circuit breaker is isolated and drawn out. Means shall be provided for padlocking the shutters in the closed position. The shutters shall be marked “BUS BARS” and “CABLES” Means shall also be provided for padlocking the circuit breaker in the plugged in position to prevent unauthorized isolating operation.
- 5.5.2 Interlocking device shall be provided so that circuit breaker can only be closed when it is fully withdrawn or fully plugged in position.

- 5.5.3 The withdrawal arrangement of a circuit breaker shall not be possible unless it is in the open position.
- 5.5.4 The circuit breaker truck can not be inserted when the earthing switch is in closed position.
- 5.5.5 Operation of circuit breaker to the “ON” or “OFF” position shall only be possible when the earthing switch is in the open position.
- 5.5.6 Closing of the earthing switch shall only be possible when the circuit breaker is drawn-out-position.

5.6 Position Indicator

The circuit breaker shall be mechanically trip free. The circuit breaker shall have mechanically operated “ON” and “OFF” position indicators. The letter shall be in white against a red background for “ON” and green background for “OFF” position.

5.7 Control Wiring and Termination

- 5.7.1 Control wiring of current and voltage circuit shall be with single strand PVC insulated copper conductor wires of sizes 4.0mm² and 2.5mm² respectively. All control wiring shall be through channels with removable covers to provide ease in inspection / replacement. The end of wires shall have permanent fiber or plastic identification ferrules.
- 5.7.2 Earth control wire shall terminate at each end in a terminal block with either a pressure connector or spade type terminal. The terminal blocks shall be provided with slip-on covers to avoid accidental touch. One spare terminal strip shall be provided for each terminal block with minimum 15 number of terminals.

5.8 General Arrangement of Circuit Breaker Panel

The general arrangement of circuit breaker panel shall be as per Annexure-A. The dimensions should exactly correspond with the drawing to ensure coupling of circuit breaker panel with the existing installed Panels.

5.9 Insulation and Clearance

The minimum clearance in air for busbars and other live parts i.e. between phase to phase and phase to earth as shown in the attached drawing. Individual panels shall be designed for insulation levels as per International Standards following the supply system as mentioned in this specification (Clause-4, Sub clause 4.1).

5.10 Enclosure/Housing

- 5.10.1 All live parts including busbars, connections, circuit breakers etc. shall be suitably enclosed in an enclosure (Housing) made of sheet steel of minimum thickness 2mm (16 SWG).
- 5.10.2 Access to bus bar, main connections and all other items of the equipment for all normal maintenance operations shall be through hinged doors with locking facilities from the front and a bolted plate at the rear for approach to the in-coming and out-going terminals.
- 5.10.3 The instrument/metering compartment door shall be properly lockable and sealable.
- 5.10.4 The earth terminals shall be readily accessible and placed so that the earth connection is maintained when the cover or any moveable part is removed. The earth terminal shall be suitably protected against corrosion and marked with the sign.
- 5.10.5 All steel sections used for the construction of enclosure shall be rigidly moulded and the entire enclosures shall be rigid and self-supporting.
- 5.10.6 The enclosure shall be completely vermin proof with special regard to the danger of flashover, both in service and isolated position.

- 5.10.7 Clamps for clamping and bonding the armour of the cables of the terminal boxes shall be provided for upto 300mm² XLPE insulated aluminum conductor cable.

5.11 Earthing / Earth Switches

- 5.11.1 Provision shall be made for earthing the panel. A bolted type connector capable of receiving a 50 mm dia. Stranded conductor shall be provided near the bottom of the enclosure. The connector shall be made of brass and shall be tin-plated. All metal parts of the installation shall be bonded so as to be effectively earthed. Door shall be connected to the body of the enclosure by means of flexible earthing strap or cable and the hinges shall not be relied upon for earthing.
- 5.11.2 Earthing switches for outgoing feeders shall be hand operated, high speed type with rated peak withstand current of 45kA.
- 5.11.3 Interlocking shall be provided to allow closing of earthing switches only in the event that the circuit breaker trolley is in draw-out position.

5.12 Painting

All the interior and exterior surfaces of the enclosure shall be thoroughly cleaned and sand blasted to prepare the metal surface for painting. The paint shall be applied as under:

- 5.12.1 Three coats of paints shall be applied. The first coat shall be a primer of Zine Chromate (Phosphate) and red oxide, which has equivalent weather resistant and rust inhibiting properties.
- 5.12.2 The second coat shall be based on a synthetic resin with excellent weather resistant properties.
- 5.12.3 The third finish coat shall also be based on a synthetic resin and shall have hard durable surface and excellent weathering properties.
- 5.12.4 The total paint thickness shall be at least 0.12mm.
- 5.12.5 Finish colour shall be steel grey outside and inside.
- 5.12.6 Alternatively oven baked painting having durable weather resistant properties or powder coating paint shall be preferred.
- 5.12.7 A danger notice in English "DANGER 11000 VOLTS" and also its urdu translation shall be stenciled red paint on the door. The height of letters and figures shall be 100mm.

5.13 Instruments

- 5.13.1 The indicating instruments and meters shall be manufactured and tested in accordance with IEC Publication-51. The indicating instrument shall be flush mounted, back connected, dust proof switchboard type. The scale plate shall have a permanent white finish with black graduation and numerals along with instrument transformer ratio for which instrument has been graduated and prominently marked. The zero adjuster shall be provided outside the instrument. All instruments shall be tropicalized.
- 5.13.2 Ammeters shall be suitable and robust enough to withstand the momentary large current arising in the circuit during short circuit conditions without damage or loss of accuracy.
- 5.13.3 All instruments together with their accessories shall comply with the requirements appropriate to their accuracy class when they are continuously loaded at their upper measuring limit under reference conditions specified in Table-III & IV of IEC publication-51.
- 5.13.4 The accuracy shall be class 1.5 for ammeters and voltmeters in accordance with IEC-51.

- 5.13.5 The metering compartment shall be separately lockable and sealable from outside. No access to metering circuit shall be possible (even with panel de-energized and breaker trolley removed) without breaking the seal and opening the locks.

5.14 Particulars of Equipment and Fittings to be Provided

- 5.14.1 The circuit breaker panel shall be provided with the following equipment and fittings:

- a) One-Ammeter conforming to IEC-51 (Range according to CT ratio)
- b) One-Ammeter selector switch.
- c) One voltmeter conforming to IEC-51 (Range according to PT ratio)
- d) One voltmeter selector switch.
- e) One handle for withdrawal/engagement of C.B. trolley
- f) One handle for manual charging of spring.

5.14.2 Current Transformer

One set of three (3) Epoxy Resin current transformers double wound secondary for operating indicating instruments, protective relays and metering with following features conforming to **K.E.** Specification and IEC-185.

- | | | |
|----|--|--------------|
| a) | Current Ratio | 400/5/5 Amps |
| b) | Accuracy class (Measuring Core) | 0.5M5 |
| c) | Accuracy class (Protection Core) | 5P20 |
| d) | VA burden (Protection Core) | 15 VA |
| e) | VA burden (Measuring core) | 10 VA |
| f) | Rated one minute power frequency withstand voltage | |
| | i) Primary winding | 28 kV |
| | ii) Secondary winding | 02 kV |
| g) | Lightning impulse withstand voltage | 95 kV |

5.14.3 Potential Transformer

Three single phase epoxy resin type voltage transformers for operating meters, time switch and indicating instruments. The voltage transformer shall be in accordance with IEC-186 and of following ratings.

- | | | |
|----|--|---|
| a) | Actual transformation ratio | 11000 / 110 V
3 3 |
| b) | Rated sec. output | 100 VA |
| c) | Accuracy class | 0.5 |
| d) | One minute power frequency withstand voltage | |
| | i) Primary | 28 kV |
| | ii) Secondary | 02 kV |
| e) | Lightning impulse withstand voltage | 95 kV |
| f) | Limit of temperature rise | As per IEC-186 |
| g) | Rated voltage factor ---- | 1.2 for continuous duty and 1.5 for 30 second duration. |

5.14.4 Meters

Electronic multi-tariff energy meters suitable to measure and record kWh. MDI and kVAh. The meters shall be manufactured and tested in accordance with IEC-521, IEC-211, IEC-145 and IEC-1036 amended to date.

5.14.5 Relays

- a) The overcurrent and earth fault relay shall be in the form of single unit containing at least two overcurrent elements for phases and for earth fault protection. The relay shall have draw-out feature for its active part from the enclosure. The front of the relay shall be covered with suitable transparent plastic material fastened to the enclosure with easily removable screws.

The relay shall be either induction or static type with non-directional feature. The relay shall have definite minimum characteristic or in case of static relay with multiple choice. Each element of relay must contain an instantaneous unit for short-circuit protection.

The relay shall be self-powered i.e. requiring no auxiliary supply. They shall be operated from the fault current supplied through secondary of current transformers and its contacts shall be capable of making and breaking trip coil currents upto 150 Amperes. Auxiliary contacts shall be provided for A.C. series trip mechanism for indicating breaker trip.

b) Settings

Overcurrent relay:

Current range

These settings shall start from at least minimum of 50% to 200% expressed as a percentage of rated current (I_n) of relay / CT i.e. 5A. The setting range shall be stepless or in the forms of steps at least 25% expressed as a percentage of rated current (I_n).

Short circuit range

It shall be in the range of $2 \times I_n$ to $30 \times I_n$.

Earth Fault Relay:

Overcurrent range

It should at least start from 10% to 80% expressed in term of I_n .

Short Circuit range

It shall be in the range of 2 to 30 times expressed against the basic rating of 1.0 ampere of earth fault relay.

c) Indication

IN case of Induction type relay, indication for relay trip command shall be provided in the form of mechanical flag preferably marked with red colour whereas for static type it shall be in the form of either LED or mechanical indicator. There should be separate indication for over-current and instantaneous elements. The indication shall not be self-reset. A knob or push button shall be provided in front for manual reset.

6. TESTING AND INSPECTION

Complete switch gear with enclosure, current transformers, voltage transformers, busbars, post insulators and earthing switch, etc. will be subjected to routine and type tests in accordance with relevant clauses of IEC Publications No.56, 298 and 6594. The current transformers, voltage transformers, earthing switch & post insulators shall be tested separately to confirm the claimed values.

The following are the type and routine tests:

6.1 Tyre Tests

The type tests shall be performed on a circuit breaker identical in all essential details with those to be supplied including the following tests:

- a) Di-electric withstand voltage tests comprising:
 - Lightning impulse withstand voltage test
 - One minute power frequency withstand voltage test
 - Power frequency voltage withstand test on auxiliary and control circuits.
- b) Short time peak withstand current tests on main and earthing circuits.
- c) Temperature rise test according to temperature limits as per IEC standards and shall not exceed the limits set forth therein.
- d) Verification of making and breaking capacities.

- e) Verification of degree of protection of persons against approach to live parts and contacts with moving parts.
- f) Measurement of leakage current.
- g) Mechanical and electrical life test to determine the service life of breakers. The number of make and break operations shall be as per International Standard and shall be defined clearly by the bidder.
- h) X-radiation test.
- i) Small inductive current breaking test.

6.2 Routine Tests

The routine test as per IEC 56-4 shall comprise the following:

- a) Power frequency voltage dry test on the main circuit.
- b) Voltage test on control and auxiliary circuit.
- c) Measurement of resistance of the main circuit.
- d) Mechanical operation test.

6.3 Report (Certificate) of Type Tests

The type test report shall be supplied with the bid for the proposed circuit breaker with record of alternations which have been made to the circuit breaker subsequent to type test. Type test report shall give sufficient information to identify the circuit breaker. In case the bidder is unable to produce respective type tests report with the bid, the test shall be carried out by a recognized independent international Laboratory OR High Voltage & Short circuit Lab., RAWAT, Islamabad in the presence of **K.E.** Engineer at the cost of the bidder.

6.4 Sample Tests

6.4.1 General

The following tests shall be carried out in the presence of **K.E.** Engineer of the selected samples of indoor 11kV vacuum circuit breaker panels:

- a) Visual inspection
- b) Verification of dimensions of various components including thickness of mild steel and paint.
- c) Functional tests of all major components according to the specification and relevant IEC standards.

6.4.2 Visual Inspection

The various components of circuit breaker shall be inspected in accordance with the list of defects set forth below:

- a) Material
 - i) Parts not made of material as specified.
 - ii) Any component missing/damaged.
- b) Finish
 - i) Dirt, grit or foreign matter embedded in finishing.
 - ii) Painting work not in order.
 - iii) Pits, cavities on the surface of main contacts and busbars. The contact surface are not smooth and uniform in thickness.
 - iv) Steel parts rusted.
- c) Construction
 - i) Construction of any major components not as per specification and good engineering practice.
 - ii) Nuts and bolts not tight.
 - iii) Doors of enclosure do not fir properly.
 - iv) Welding not proper.
 - v) Locking arrangement not proper.

vi) Earthing steps between doors and enclosure not of adequate size.

d) Marking / Name Plate

i) Missing, not legible, incomplete or not permanent.

7. RATING PLATE AND PACKING

7.1 Rating Plate

The rating plate of non-corrodible material for each panel shall be fixed on the front of the enclosure. The plate shall include but not limited to the following information:

- a) Manufacturer's name or trademark and year of manufacturer.
- b) Manufacturer's type designation and serial number.
- c) Rated short time withstand current (1 Second)
- d) Rated Voltage
- e) Rated current
- f) Breaking capacity
- g) Rated frequency
- h) Rated insulation level (i.e. for lightning impulse and one minute power frequency)
- i) Current ratios of CTs and voltage ratios of PTs.
- j) Connection diagram.

8. GUARANTEE

The supplier shall make good by repair or replacement any faulty / damaged part which has been damaged solely due to design defect or improper workmanship within one year after the commissioning of the panel. It is emphasized that the guarantee period shall be reckoned from the date of commissioning and not from the date of supply.

9. MV CABLES

The MV cables, to IEC 502, shall be 3 core compacted stranded copper conductor, extruded semi-conducting screened, cross-linked polyethylene insulated, semi-conducting screened, copper tape shielded, laid up with suitable fillers to make a circular shape and wrapped with binder tape. The cable shall be galvanized steel wire armored over extruded PVC bedding with overall black PVC sheath. The voltage rating shall be 15000 / 8700V, and the cores shall be identified. The size, specification, and make of the cable shall be embossed on the sheath at 1.0 meter intervals (maximum).

10. TESTING & COMMISSIONING

Testing shall be conducted in two phases.

At the manufacturer's work, the following tests shall be performed as a minimum, and the results recorded on test reports sheet. These reports shall be submitted to the Engineer three days before the equipment is ready for witnessed testing.

10.1 MV panels

- a. Circuit breakers / RMU operation
 - Protection relay operation
 - CT polarity check
 - CT magnetizing cures
 - IDMT relay characteristics check (primary injection)
 - Insulation tests
 - Tripping circuits check
- b. Energy metering tests
- c. Buchholz and temperature alarm / trip circuit tests
- d. Megger tests
- e. MV tests
- f. Any other tests as mentioned else where in these documents.

10.2 Transformer

- a. MV tests, megger test, turns ratio test, resistance test, no load test, winding over frequency test, short circuits test, oil dielectric strength test.
- b. Bucholz gas relay test.
- c. Temperature alarm / trip test.
- d. Any other tests as mentioned else where in these documents.

Important Notes:

1. The bidder is required to visit the site to familiarize him self about scope of works, before quoting his prices.
2. The electrical installations shall be suitable for 15KV / 12KV / 11KV, 400/230V 3/1 phase 5-Hz supply as required (except otherwise stated). And conforms to requirements of local Electrical authorities and IEE regulations. The electrical installations shall be completed in all respect. It is Contractor's responsibility to obtain approval of electrical installations from Electric Inspector, Government of Sindh.
3. All conductive but non current carrying parts of electrical installations shall be earthed properly.
4. Cables / wires color codes for different phases, neutral, earth should be followed and load balancing shall be achieved.
5. The routing and height of cable tray / trunking shall be as directed by Architect / Consultants.
6. Electrical works to be coordinated with other services.
7. Submit samples of materials or its technical submittals to Consultant for approval before manufacturing / installation.
8. Submit 3 sets (min) of shop drawing to Consultant for approval before manufacturing / installation.
9. As built drawings 3 sets (soft & hard copies) to be submitted.
10. Any item(s) of BOQ can be taken away or reduce or increase in quantity if Client / Consultant desire so. It shall no affect price structure of remaining part of contract.
11. Any material, if not found in accordance with tender / contract drawings / BOQ / specification during or after installation(s), even in use and paid for, shall be replaced by contractor, at no extra cost to client. Any delay in such replacement shall be chargeable by client appropriately from contractor.
12. All material shall be new, latest in technology and latest manufactured from the manufacturer's line of production. Old models if used shall not be acceptable and shall be replaced by contractor at their own cost & risk. Any payment made in respect of un-proper work not satisfactory in view of Consultants and clients) shall be liable for accounts adjustment and refunded to Clients, if demanded so by Consultant / Clients.
13. GST & other taxes should be included in the prices.

GENERATOR WORKS

1. GENERAL

The work consists of supplying, installing, testing and commissioning of all material and services of Diesel generating set(s) including control panel as specified herein, shown on the Tender Drawings and given in the Bill of Quantities.

The Diesel generating set(s) shall be a standard design of reputed manufacturer, who shall have similar units in operation for similar applications and field conditions. The manufacturer shall also have adequate maintenance facilities in the vicinity of Project with technically qualified and experienced personnel trained for operation and on-site maintenance of equipment offered by the Contractor in the bid tender.

The capacity of set shall be rated for prime duty (prime – KVA) at site. However the DG set shall be used for stand by or continuous duty and suitable for outdoor installation in weather proof acoustic canopy. It shall be capable for unbalanced loads up to 30% of actual load and for continuous part load operation. The set shall be capable of starting and operating at the rated output at fifty degree Celcius 90% Relative Humidity and at an altitude of 2500 metres above mean sea level. The ratings must be substantiated with manufacturer's standard published data.

The Diesel generating set(s) after reducing the power absorbed by the auxiliaries, shall deliver continuously rated power output under the site conditions. All auxiliaries, accessories and connections between systems alongwith all necessary cables, fittings, hardware, etc. for complete installation of Diesel engine, generator, control panel, including fuel and oil storage, exhaust system, etc. shall be furnished by the Contractor.

The engine shall be directly coupled to the alternator, and shall have a rated speed of 1500 rpm. The set shall be capable of sustaining without damage, 25% overspeed, under any abnormal operating condition.

The engine-alternator set shall be mounted on suitable rigid steel frame skid with vibration isolators. Heavy duty lifting eyes and jacking screws shall be provided on the skid. The foundation bolts shall be furnished with the set. Any excessive torsional vibration shall be avoided for both engine and alternator.

The set shall be suitable for full load starting. When the generator is operating at no-load, the application of full load current, taking into account the surge due to starting of equipment, should be possible with maximum transient voltage drop of 15% of the rated voltage. The time taken to restore the generator voltage to 97% of rated value should not exceed 3 seconds.

The set shall be capable of starting and accepting full load within 15 seconds after receipt of starting signal.

The Contractor shall submit the equipment layout and other installation details as per manufacturer's recommendations for approval of the Engineer.

The work also includes fabrication, furnishing, installing and testing of the steel fuel tanks, fuel pumps, piping, pipe fittings, and allied accessories as described in this specification and Bill of Quantities and as shown on the Drawing complete in all respects, including coating and lining wherever required.

The details and technical data concerning Diesel generator set shall be submitted with the tender bid. Where required the documents from the manufacturer shall be furnished to the Engineer in support of the information furnished.

The Diesel engine and generator set shall conform to the following standards as applicable.

- | | | |
|------------|---|---|
| BS 5514 | - | Reciprocating Internal Combustion Engine. |
| BS 4999 | - | General Requirements for Rotating Electrical Machines. |
| BS 5000-99 | - | Rotating Electrical Machines of particular types or for particular application. |

- DIN 6616
 - Horizontal Steel Tanks for the storage above ground of petroleum products in liquid form.
 - Steel Tank for storage underground of petroleum products in liquid form.

2. DIESEL ENGINE

The Diesel Engine shall be four stroke, compression ignition, 1500 RPM suitable for standby / continuous duty.

Engine de-rating for site should be taken in to account to determine required site rating.

Starting shall be through electric starter motor operated on DC supply from lead acid batteries mounted on the skid. The batteries shall be furnished with the set.

The engine shall be equipped with an alternator type automatic charging system to charge the batteries during running of engine. A static battery charger installed in the control panel shall also be provided to charge the batteries when the engine is not running. Suitable interlocks shall be provided to prevent simultaneous operation of both charging systems. The batteries shall be of adequate ampere - hour capacity to satisfy the following requirements:

- a. Crank the engine at firing speed for at least 15 seconds.
- b. If the engine does not start on the first attempt, crank the engine two more times for the above duration at an interval of 30 seconds between each cranking operation.

Engine shall be rated for continuous duty with overload capability for operating at least 10% above the rated capacity for 1 hour continuously in any 12 hours operation.

2.1 Air Intake

Air intake shall be through turbo charger and equipped with dry type filter. Suitable attenuators shall be installed to reduce noise at the air inlet.

2.2 Engine Cooling

Engine shall have a forced air-draft, water cooled tropicalized radiator supplied with a core guard. Cooling system shall have an engine driven centrifugal pump for cooling water circulation. Cooling shall be thermostatically controlled. An engine shut down timer shall be provided to keep the engine running on no-load after any operation of set, so that the engine is sufficiently cooled to start again instantly, if required, without rise in temperature above safe limits. Exhaust air from the radiator shall be ducted through the air chamber into atmosphere. Adequate ducting system shall be provided for this purpose ensuring satisfactory cooling.

2.3 Engine Lubrication

A gear type positive pressure lubrication pump shall be provided with efficient filtration arrangement for the lubrication system. A 230V AC main operated heater with thermostat shall be provided in crank case.

The heater shall be designed for automatic switching to ensure that temperature of oil is maintained for proper operation of the engine.

Engine shall have a constant oil level regulator, gravity fed from an engine mounted lube oil reservoir. Reservoir shall be equipped with an oil level gauge. The crank case shall have graduated dip stick with low and full level marks.

2.4 Exhaust System

Exhaust system shall be equipped with residential type silencer complete with muffler, exhaust manifold, flexible connector, exhaust elbow, exhaust pipe, raincap, and associated fittings. The exhaust line shall be taken outside the canopy through the shortest possible and practical route, without any undue bends. This exhaust line shall be adequately covered with insulation material

over its entire length i.e. from the engine to the termination point. All supports for exhaust system shall be furnished. The silencer shall be mounted on top of the canopy with all fixing accessories.

2.5 Speed Governor

Electronic Governor shall regulate engine speed so as to maintain the generator frequency within plus or minus 0.5% of the rated frequency. Stable engine speed shall be attained within 10 seconds after the engine has been started. Stable engine speed shall be restored within 5 seconds of any sudden change in load, from no load to full load. During this change of load or surge, the speed shall not vary by more than plus or minus 5% of the rated speed.

2.6 Fuel System

Engine shall operate on commercial high speed Diesel oil. A fuel oil strainer/filter shall be provided in the fuel line. Fuel system of Diesel engine shall be without priming pump. Fuel system shall be direct unit injection.

The fuel storage system shall comprise of the following:

The storage tanks should follow applicable codes of DIN and local Governmental codes: -

- One main underground storage tank installed underground with a capacity good for 4 days continuous operation of both DG sets.
- Fuel transfer system with controls, pumps etc.
- Piping with fittings, valves etc.

The main fuel storage tank shall have required capacity and dimensions shall suit the space available. The tank shall have level switches for remote (control room) monitoring of low and high fuel level in the tank with audio-visual indication and wiring. The low level switch shall provide an annunciation. The tank shall be provided with overflow, vent, supply valves, inspection cover.

The fuel storage tank shall be of mild steel plates of required thickness and shall be designed, fabricated and finished in accordance with the requirements of DIN 6616 & DIN 6608 Horizontal Steel Tanks for the Storage and NFPA compliance flammable and combustible liquid codes. Also applicable are standards in practice in Pakistan. All joints should be lap welded.

The fuel tank shall be supported on suitable concrete / steel base. The fuel tank and structural steel work shall be protected from corrosion by two coats of Red Oxide and two coats of enamel paint as per petroleum product codes.

The storage tank shall be properly cleaned internally and externally from any oil, grease, surplus welding material and flushed with solvent and dried.

The fuel storage tanks must be chemically inert to petroleum products being stored.

Lifting lugs on top of the tanks must be provided, designed for 3:1 safety factor.

Certification plate: Provide plate bearing certification, permanently affixed to the tank.

A system for filling-up the fuel storage tank by oil tanker from outside the building with pipe work, valves etc. shall be provided. All interconnected piping, valves, etc. shall be furnished. Underground piping shall be treated with bituminous tap/felt as approved by Consultant.

Diesel fuel pipe work should be black steel pipe comply to ASTM-A53 grade A schedule 40 welded or seamless as approved. The fuel piping to be furnished shall include fuel supply pipe from storage tank to Gen sets, drain pipe and other piping as shown in the drawing and required for a complete system.

Shop drawing indicating arrangement of pipe work with respect to the location of equipment shall be prepared by the Contractor and submitted to Engineer for approval. A full flow fuel filter shall be installed in the fuel supply lines with a by-pass arrangement.

Grounding: Electrically ground fuel oil tank/piping system and bond tightly to grounding electrodes. The price to be built in, in the works.

3. GENERATOR

The generator shall meet requirements detailed in BS 4999/5000, IEC 34-1, VDE0530.

The generator shall be synchronous. The generator shall be capable of carrying, continuously 10% over load of rated output with the field set for normal rated load excitation for 1 hour in every 12 hours operation. It shall be 4-pole, screen protected and drip proof to IP22 grade.

3.1 Excitation

Exciter shall be permanent magnet type. Excitation shall be from brushless rotating diodes mounted on the main shaft for 3-phase full wave rectification.

3.2 Windings

Alternator windings shall have Class H insulation and shall be impregnated for tropical use. The temperature rise of winding under normal operating conditions and at rated load shall not exceed the limits specified for Class F insulation. Anti condensate heaters shall be provided for windings. The heaters shall be thermostatically controlled for switching ON after the set has stopped. The thermostat range shall be adjustable and set to prevent overheating of windings. For protection of windings from damage due to over heating, thermostat shall be embedded to stop the set in case the temperature of windings rises above the safe value.

3.3 Voltage Regulation

Automatic Voltage Regulator shall be solid state type with provision for manual setting. Regulator shall be so designed to protect the exciter when the set is running at reduced speed during starting or idling of the prime mover.

Voltage regulation shall be plus or minus 0.5% from no-load to full load. Transient voltage drop shall be less than 15% at full load and 0.8 power factor. Time required to restore to steady state conditions after transient voltage fluctuation shall not exceed 5 seconds.

3.4 Short Circuit Capability

Generator shall withstand, without injury, a 30 seconds three phase short circuit at its terminals when operating at rated output and power factor with fixed excitation.

3.5 Generator Panel

The generator panel shall be designed for front access, completely assembled, wired and tested. The control panel shall be microprocessor based including generator set monitoring, metering, control and display features. It shall be to IP54 grade.

The panel shall incorporate protection and control equipment, measuring instruments, control and instrument transformers, voltage regulator, governor controls, battery charger, indicating lamps, auto mains failure system, safety devices, enunciator, etc.

The panel shall incorporate 2 Nos. volt free auxiliary contacts (for starting another generator) in case this generator fails to start due to some fault or other reasons.

3.5.1 Circuit Breaker

The circuit breaker shall be triple pole with adjustable releases for thermal overload, instantaneous over current, under voltage and over voltage.

3.5.2. Instruments

- i. Ammeter with selector switch
- ii. Voltmeter with selector switch
- iii. Frequency meter
- iv. Kilowatt-hour meter

- v. Ammeter for battery charging current
- vi. Kilowatt-meter.
- vii. And as mentioned else where

3.6 Engine Panel

An instrument panel on the skid shall have calibrated gauges/metres to measure the following:-

- i. Engine speed
- ii. Lube oil pressure
- iii. Lube oil temperature
- iv. Engine water temperature
- v. Engine running hours
- vi. And as mentioned else where

3.7 Safety Devices

Following safety devices shall be provided. The audible alarm shall operate on any fault condition and shall be resettable manually and automatically through a timer after 15 minutes whichever is earlier.

A= Alarm		SD = Shutdown	TD = Adjustable Time Delay
i)	Engine Overspeed	A	SD
ii)	Low Lube oil pressure	A	SD
iii)	High water temperature	A	SD
iv)	Over voltage	A	SD(TD=0-30 Sec.)
v)	Under voltage	A	SD
vi)	Short circuit & Tripping of Circuit breaker	A	SD (TD=0-1 min.)
vii)	Low level in fuel storage tank	A	SD (TD=0.5 min.)
viii)	Winding temperature high	A	SD (TD=0-2 min.)
ix)	Overcrank	A	SD (After 3 successive Crankings)
x)	Low crankcase oil level	A	
xi)	High crankcase oil level	A	
xii)	Charging alternator failure	A	
xiii)	Charger failure	A	
xiv)	And as mentioned else where.		

For all shut down conditions the set shall lockout and it shall not be possible to start it unless manually reset after the cause of fault has been removed.

3.8 Battery Charger

Battery charger shall be static type and shall provide for both trickle and boost charging of the batteries when the engine is not in operation. The charger shall be of suitable capacity to fully recharge the completely discharged batteries within four hours boost charge.

3.9 Mains Failure Sensing Unit, 3-phase, Adjustable

The panel shall incorporate automatic changeover system which shall be designed for the following functions:-

- (a) To start the sets immediately when the mains supply fails or when phase sequence is reversed.
- (b) To start the sets within 0 to 1 minute (adjustable) whenever the mains supply voltage drops to 360 volts or rises to 440 volts. The setting voltages shall be adjustable within - 5% to + 5% respectively for the lower and upper ranges.
- (c) To transfer the load from standby generator to main supply whenever the mains voltage returns $\pm 5\%$ and persists for at least 3 minutes. (where applicable)
- (d) To make two successive attempts, in case the set(s) fail to start in the first attempt.

- (e) The system shall provide for immediate transfer of load to the generators, after the rated speed/frequency and voltage have been achieved. (where applicable).
- (f) The system shall be self resetting after each cycle of operation.
- (g) A four position selector switch shall be provided for selecting the operation Mode i.e. Automatic-Test-Manual-Stop/Maintenance mode.
- (h) Changeover shall be effected by the operation of Automatic Transfer Switch (ATS) located in main electric room. Control wiring for changeover is to be provided between generator panel and the ATS as per requirement. (where applicable)

3.10 The contractor shall arrange following site tests at his own cost including providing of load bank, if required by Consultant.

- i) Operation of all panel meters, gauges and other indicators.
- ii) Demonstration of workability of safety devices & controls.
- iii) Full load test for 4 hours and 110% load for one hour.
- iv) Test of any other feature as described in this specification.
- v) And other tests as mentioned else where.

4. LOCALLY FABRICATED ACOUSTIC CANOPY

The sound proof (sound reducing) canopy shall be designed in such a way that it reduces the engine and the alternator sound to 75 dB at 1 meter. The canopy is to be fully steel structured. A portion of the doors shall have louvers for air in take, cooling and louver's opening in the doors shall be calculated to have more area than the drought out let.

Acoustic canopy shall be constructed from pre-formed heavy gauge mild steel sections with a 3mm thick plate (Pak Steel). The canopy shall be weather proof, scratch proof and corrosion resistant. The color shall be chosen by the Engineer. The canopy shall have vandal resistant locks with substantial hinges. Interior shall be lined with a high density layer of sound absorbing mineral wool and specially treated with heat resistant chemical, before laying in the necessary portion from inside the canopy including the roof portion with perforated metal sheets. It shall be spray painted after application of two coats of primer.

The mineral wool shall be retained in position with perforated minimum 22 SWG steel sheeting having an area not less than 40%. Air tight rubber shall be applied to all external joints. A shield plate and a compound sealant is to be used around the roof mounted exhaust silencer. The canopy shall be assembled and dismantle able type at site and close – fit type with proper lockable access doors and panels for operating controls and routine maintenance. Full rated continuous running of the set shall be possible with all doors and access panels shut.

It shall have a filling pipe, air vent and a mechanical fuel gauge. Enough space shall be provided in the canopy for changing of lub oil.

Base of the canopy shall be provided underneath skid structure of Generator.

5. AUTOMATIC TRANSFER SWITCH (ATS) / Where applicable

The automatic transfer switch shall be factory assembled in 14 SWG sheet steel enclosure rust proofed, phosphated and powder coated. It shall be free standing / wall mounting as per requirement. The rating shall be as drawing / BOQ. The ATS shall include the following features / accessories:

- Complete assembly with transfer mechanism.
- 4-Pole contactors with contacts rated at 500 V AC, suitable for motor loads.
- Arc chute barriers.
- Single solenoid, electrically operated, **mechanically held**.

- Ground connection.
- Disconnect safety switch.
- Indicating lights on face of panel for Normal, Standby and Standby operating.
- Main contacts shall be silver plated or silver alloy and provide resistance to sticking or welding.
- All components shall be front adjustable and front removable.
- NO and NC Auxiliary contacts for normal and standby.
- Control wiring.
- Control fuses.
- Connection terminals.
- Lockable hinged doors.

6. INSTALLATION OF GENSET

Within one week of award of contract, the Contractor shall submit a detailed itemized schedule of works covering submission of shop drawings and technical details, manufacture and works testing of generator.

The Contractor shall also submit to the Engineer a detailed shop drawing (in 3 copies) of the genset and acoustic canopies, fuel storage and delivery system, switchgear, synch and load management panel, power & control cabling, earthing, etc.

Installation of fuel tank and piping shall be in accordance with the relevant International Codes, manufacturer's recommendations and approved shop drawings.

Installation of the genset shall be carried out in accordance with the manufacturer's recommendations and the instructions of the Consultant.

The Contractor shall place the genset on steel structure or RCC pad as required with skid and vibration isolators. The weather proof canopy shall be installed as per requirement including all accessories complete in all respects. Power and control cables shall be terminated as per requirement including glands, lugs etc.

The exhaust pipe, minimum 3mm thickness, shall be connected to the exhaust manifold with flexible connector. The whole assembly shall be thermally lagged with 100mm thick mineral fiber having a density of not less than 8 kg./cu.m clad with copper mesh, and an overall cover of 24 bg GI sheet. The residential type silencer shall be installed outside the canopy on top with all fixing accessories.

The Contractor shall install the genset panel, batteries, and make all cable, earthing, and control connections in accordance with the manufacturer's wiring diagrams and instructions.

The Automatic Transfer Switch, manual changeover switch and main incoming breaker shall be installed and power and control cable shall be terminated including cable gland, lugs etc. All control wiring between generator control panel and ATS is to be carried out as per requirement. (where applicable)

All materials required for complete installation, commissioning, and testing, including but not limited to bolts, shims, pipes, ducts, hangers, vibration isolators, flexible connections, thermal lagging, brackets, radiator duct, and connections, cable glands, lugs, etc. shall be provided by the Contractor within his quoted price.

7. FACTORY INSPECTION OF LV SWITCHGEAR/ PANELS ETC.

The Contractor will arrange a visit of Consultants / Owner/ the Inspection/ testing of synch & load management panels & switchgears etc. at the Manufacturer's premises before delivery the items to site. The Consultant will have the right to object/ reject any substandard material/ panel found to be unsuitable or not in accordance with the specifications. The Contractor will required to replace the substandard material and rectify the defect/deficiency objected by the Consultants/Owner at his own cost.

7.1 Synchronization and Load Management Panels

These panels shall be of 12 / 14 SWG sheet steel fabricated floor mounting, cubicle type, totally enclosed, dust tight, degreased and vermin proof with two coats of zinc chromate and painted with two coats of spray color RAL 7032 and two coats of epoxy based paints. It shall be complete in all respect with material and accessories, factory assembled, tested and finished all according to the specifications and to the normal requirements. For indoor installations the protection classification shall be IP40.

The panels shall be for front operation and suitable for extendibility on either sides in future and should have the provisions for incoming and outgoing connections from the top or bottom with cable termination arrangements (terminal block). The panel should have the adequate clearance from live parts to avoid flashovers by switching surges, vermin's, pets etc. and all components rated for insulation class for 600 volt min and the doors grounded by flexible copper cable / strip.

7.2 The synchronization and load management panels (LV switch board) / panels so provide shall be designed strictly following the standards given below.

1. BS 4752-1 - Circuit breakers.
2. IEC 157 & - Low voltage switchgear and control gear.
IEC 158
3. BS 89 & - Ammeters and voltmeters.
BS 90
4. BS 4752 - Switchgear and control gear for voltages up to including 100volts.
5. BS 3938 - Low voltage current transformers.
6. IEC 446 - Identification of insulated / bare conductors.
7. IEC 73 - Colors for indicator lights and push buttons.
8. IEC 439 - Factory built assemblies of LV switchgear.

The equipment shall be rated 400 volts, and suitable for operation on the KESC / Generator supply. Panels shall be factory assembled, ready wired, and shall be complete with adequately rated electrolytic copper phase, neutral, and earth busbars, suitable clamps, jointing and termination accessories, line up terminals, earthing bolts, etc.

Miniature circuit breaker (MCBs) and molded case circuit breakers IEC 157 – 1 / BS 3871, shall be of the molded type with operating lever protruding through the metal safety plate. Air circuit breakers, above 630 amps, shall be installed within separate cubicles. Switch fuses and load break switches (AC 23), to BS 5491, incorporating HRC fuses, to BS 88, shall be of the heavy duty type, complete with all accessories.

The short circuit ratings (dynamic and thermal) of all switchgear assemblies shall be equal to or greater than the SC level (IEC 157 – 1, P2 at 415V) shown on the schematic diagram / BOQ. The dynamic strength of the busbars shall be 2.5 time the short circuit level. The characteristics of the protective devices shall be such as to provide selective discrimination.

CTs shall be of class 1.0 for tariff metering purposes, and class 1.5 for indicating purposes. The CTs shall have suitable burden and over current (saturation) factors. KWH meters shall be class 1.0.

All LV and power panels, shall be provided with a 15 amp 3-pin switch socket and 16 amp HRC fuse ahead of incoming.

Necessary control wiring and control fuses shall be provided.

7.3 Construction Detail

Synchronization Cum Load Management / Sharing Panels

The LV synchronization cum load management / sharing (SYMS) panel shall be fabricated with angle iron framework welded, grinded, finished and clad with 12 / 14 SWG sheet steel powder coated through paint RAL 7032 min of 60 micron coating. It shall be suitably divided into panel and compartments for accommodating the required circuit breaker, instruments / synchronous module unit, metering and accessories etc.

The “SYMS” shall be supplied with foundation bolts and internally wired with imported copper Busbars of required rating along with necessary accessories, earthing wires, fixing bolts, insulating material and stainless steel sheet circuit designation. All metal work would be completely cleaned and provided with anti corrosive base coat and outer surface finished with standard color RAL 7302 and one coat of epoxy paint min of 60 micron in addition to safe / protect from sea side climate condition.

The “SYMS” panel shall be floor mounted (free standing type) 3 phase, 5 wires, 400volts 50Hz. ICU / ICC high KA complying with ICE 157, 158, 439 and BS 4752. All the components shall be rated for insulation class 600V min CTs shall be of class 2.5, 600V, 15VA burden and protection class IP40. The SYMS panel shall be complete in all respect & ready for installation and shall be configured and equipped with following as:

The panels shall have provision for interfacing with BMS.

7.3.1 Main Features

- i. Auto / manual synchronization, auto / manual load sharing with auto / manual load management.
- ii. Necessary protection for generators.
- iii. Necessary metering & instrumentations.
- iv. Energy analyzers with SNMP.
- v. Motorized ACBs as required.
- vi. Cu Bus Bars (TPN + E) as required.
- vii. Control wiring, control fuses, terminals.
- viii. MIMIC, labeling & ferruling.
- ix. LED indications.
- x. CTs of required rating (15VA min)
- xi. Relays / timers, synch / Load management controller modules etc. are for each generator.
- xii. Synchronous scopes.
- xiii. Auxiliary terminals
- xiv. Auto synch with following functions(min).
 - Main failure - starts / stops sequence of Generators.
 - Operation of all generators & main breakers.

Synchronization

- xv. Protections
 - Over / under frequency
 - Over / under voltage
 - Voltage asymmetry.
- xvi. Engine protection with configurable alarms input / outputs.
- xvii. Generator protections alarms with definite time characteristics.
 - Over Current (2 levels)
 - Reverse Power (1 level)
 - A horn output shall be activated at each engine and or generator alarm.
- xviii. Measured & calculated values, metering to be digitals.
 - Generators
 - Voltages (3 phases U + N)
 - Current (3 phases 1)
 - KW (Active power)
 - KVAr (Reactive power)
 - Cos ϕ (Power factor)
 - F (Frequency)
 - Kwh (Engine protection)
- xix. Bus Bars
 - Voltages (3 phases U + N)
 - F (Frequency)
- xx. Display
 - All parameters - Graphic back lit LCD display 128 x 64 pixels or as advised by Consultants.
 - Parameters are adjustable via key board or PC.

7.4 Associated civil works

The cost of any civil works, (cutting, chiseling, excavation, backfilling, grouting, drilling etc. and making good) associated with any item of the electrical works shall be included in the quoted price for the item. The Contractor shall be responsible for carrying out these civil works and making good and the cost shall be deemed to be included in the quoted price.

8. APPROVAL BY ELECTRIC INSPECTOR & EXPLOSIVES INSPECTOR

The Contractor shall have the kWh meter sealed and the installation approved by the Electric Inspector. The Contractor shall have the generator and fuel system inspected and approved by the Explosive Inspector. All costs on this account are deemed to be included in the contract price.

8.1 Maintenance and Warranty

The Contractor, as a representative of the manufacturer, shall warranty the genset and system to be free from all defects for a period of one year from the date of commissioning. All defective parts shall be replaced by the Contractor free of charge. The Contractor shall train the Owner's staff in the proper operation and maintenance of the set. Contractor is responsible to provide the list of spare parts from manufacturer during the maintenance period (for 12 months).

8.2 Maintenance Service Contract

The Contractor shall be required to provide in addition to warranty, after-sales service of a standard quality, which is internationally acceptable for 12 months maintenance period or 1000 hours of operation of gen set, whichever comes first, which shall include all spares and labour, monthly visits and trouble shooting.

9. TESTING AND COMMISSIONING

During execution and on completion of the works, (as required by Consultant / Owner the following tests shall be performed before installations & after installations as required, and certification submitted to Consultant / Owner. All equipment/instruments for the tests are to be provided by the Contractor at no extra cost. All test to be performed in the presence of Consultant / Project manager / Owner or its representative Engineer.

- a) Earth Resistance test and earth loop impedance test.
- b) Insulation resistance / Meggar test of the entire electrical installation between phases, phase to earth and phase to neutral.
- c) Polarity tests on switches, MCB's, fuses, etc.
- d) Operation tests and commissioning of the entire electrical installation including all equipment.
- e) Any other test, which Owner / Consultant consider it necessary.
Certificates of Test shall be compiled, for each section of the installation. A master set of these documents shall be kept as the original of the Test Dossier. This dossier will bear the signature of Owner witnessing the tests.

In addition to site tests, a manufacturer's standard test report/certificate shall be submitted, which shall include the following as a minimum for each genset:

- (a) Load test temperature rise

25% load	½ hour
50% load	½ hour
100% load	1 hour
110% load	1 hour
- (b) Transient responses (voltage and frequency regulations)
 - (i) application and rejection of Block load 0 _____ 60%
 - (ii) rejection of block load 100 _____ 0%
- (c) Operation of automatic starting, control sequence, and all protection circuits/sensors. Operation of ATS. Transfer of load on mains supply failure and on restoration of mains supply.

Prior to acceptance of the installation, the equipment shall be subjected to an on-site test with full load for a minimum period of 4 hours, plus one hour at 110% load, at contractors expense including provision of load bank.

All operating fluids (including fuel, oil, lubricants, coolants, inhibitors, etc.) for the testing shall be provided by the Contractor, who shall commission the genset, making all initial adjustments and settings required, and test all the control and protection functions and circuits. Three copies of the witnessed test-report shall be submitted to the Engineer.

DATA TO BE FURNISHED BY CONTRACTOR

1. Detailed technical literature and specifications, and current production status of engine and alternator for each genset.
2. Engine data :
 - a) Type/Make : _____
 - b) Country & Year of Manufacture : _____
 - c) Name & Address of local agent : _____

- d) Normal prime power rating : _____ BHP at 1500 rpm at _____ deg.C ambient temperature and _____ m altitude.
- e) Site Standby power rating _____ BHP at 1500 rpm at 50 deg.C ambient temp. and 300m altitude.
- f) No. of cylinders _____ arrangement _____
- g) Bore _____ mm, Stroke _____ mm, Piston displacement _____ mm cubic.
- h) Piston speed _____ m/s. At 1500rpm, BMEP _____ N/m sq. @ rated kW output.
- j) Aspiration _____

3. Alternator Data:

- a) Type/make _____
- b) Country & Year of manufacture _____
- c) Name & Address of local agent _____
- d) Normal continuous power rating _____ kW at 1500 rpm at 400 volts at _____ deg. C temp. And _____ m altitude.
- e) Site standby power rating _____ kW at 1500 rpm, at 400 volts at 50 deg.C ambient temperature and 300m altitude.
- f) Number and type of bearings _____
- g) Exciter type _____
- h) Telephone influence factor _____
- j) Short circuit withstand _____ percent, for _____ seconds.
- k) Overload withstand _____ percent, for _____ minutes.

4. Generating Set Data:

- a) Type / Make _____
- b) Country of Origin : _____
- c) Name and address of local agent _____
- d) Normal continuous power rating _____ kW at 1500 rpm at 400 volts, at _____ deg.C and _____ m altitude.
- e) Site standby power rating : _____ kW at 1500 rpm at 400 volts, at 50 deg. C and 300m altitude.

5. Engine manufacturer's certified curves for

- a) Engine BHP
- b) Fuel consumption at various loads (25%, 50%, 75%, 100%, 110%)
- c) Lube Oil consumption at various loads (25%, 50%, 75%, 100%, 110%)

6. Information on the set's motor starting capabilities, including maximum kVA/ voltage dip, and maximum kW characteristics.

7. Number of operating hours to major overhaul _____.

GENERATOR TEST FORM

NAME OF CUSTOMER : _____

ADDRESS OF INSTALLATION : _____

GENSET MAKE + MODEL NO. : _____

GENSET SERIAL NO. : _____

ALTERNATOR SERIAL NO : _____

ALTERNATOR MAKE + MODEL NO. : _____

ENGINE MAKE + MODEL NO. : _____

ENGINE SERIAL NO. : _____

GENSET CONTINUOUS/PRIME POWER RATING : _____ KVA _____ KW
@ 0.8 pF

RATED VOLTAGE : _____ / _____ VOLTS

SYSTEM : 3 PHASE, 4 WIRE

FREQUENCY : 50 HZ

SPEED : 1500 RPM

CONTROL SYSTEM : MANUAL/AMF/SYNCHROMIZING

DATE OF TESTING : _____

SIGNATURE OF OWNER/CONSULTANT

SUPPLIER

SIGNATURE OF ENGINEER

RECORDED BY : _____
TESTED BY : _____
DATE : _____

Diesel Generating Set

Project: D.G. Set for _____

Date: _____

Vender is required to fill this proforma.

Permanent Safety Features (Protection & Indications)

	Low oil pressure shutdown	Required	Yes	_____
	High water temperature shutdown	Required	Yes	_____
S.#	Description	Specified / Required		Offered by Vendor
1.	Prime, Stand by duty			
2.	Ambient temperature	50C°		
3.	Altitude	2500m		
4.	D.G. set – Make Country			
5.	Engine – Make Country, Year of Manufacture			
6.	Alternator – Make Country, Year of Manufacture			
7.	Year of Manufacturer of entire D.G. Set			
8.	Name and address of local agent			
9.	Canopy (70, 75, 80 & 85 db.) at 1 meter	75 db		
10.	Anti-vibration pad Between concrete floor and skid of D.G. set	Yes		
11.	Electric governor	Yes		
12.	Drop kit for parallel operation	Yes		
13.	Turbo charger	Yes		
14.	Engine speed	1500 RPM		
15.	Voltage, Frequency	400Volt, 50hz.		
16.	Residential silencer	Yes		
17.	Winding class “H”	Yes		
18.	Exaltation	Self excited PMG Type Yes /		
19.	Aspiration			
20.	Power Factor	0.8 logging		
21.	Double battery charger	Yes		
22.	Special features required as per attached sheets – pages 2/4 & 3/4.			
23.	Base fuel tank	Yes		
24.	AMF Provision	Yes		
25.	10% over load for one hour	Yes		
26.	Fuel consumption per hour at 25%, 50%, 100% load			
27.	Concrete base 12” high	Quote rate		
28.	Warranty	One year		
29.	One year maintenance Consumable provided by client / vendor.	To be included Yes / No.		
30.	Delivery & completion period			
31.	GST or other taxes / duties	To be included Yes / No.		
32.	Electric inspector approval	To be included Yes / No.		
33.	Nett. Price of D.G. set including all above required features & inclusive of all taxes	In Pak. Rupees		
34.	Validity period of prices			

Over speed shutdown	Required	Yes	_____
Under speed shut down	Required	Yes	_____
Over crank shout down	Required	Yes	_____
Over winding temperature protection	Required	Yes	_____
Over load release	Required	Yes	_____
Short circuit release	Required	Yes	_____
Under voltage release	Required	Yes	_____

Anti vibration dampers	Required	Yes	-----
Fail to start	Required	Yes	-----
<u>Optional / Required Safety Features (Protection & Indication)</u>			
Over voltage	Required	Yes	-----
Over current	Required	Yes	-----
Low coolant level monitoring	Required	Yes	-----
Low & high oil level monitoring	Required	Yes	-----
Fuel heater	Optional	Yes / No	-----
Oil sump heater	Required	Yes	-----
Oil temperature protection	Required	Yes	-----
Emergency stop switch	Required	Yes	-----
Remote emergency stop switch	Optional	Yes / No	-----
Jacket water heater	Required	Yes	-----
Under speed	Required	Yes	-----

Monitoring Control Panel

Engine Controller:

Solid state engine controller module through micro processor technology.

Yes

Indications (all required)

Yes

Circuit breaker on / off / tripped

Low oil pressure

High water temperature

Over speed

Under speed

Battery charging

Metering (all required):

Voltage, line to line & line to neutral

Current for each phase

Frequency

RPM (Optional)

Hour run

Fuel level gauge

Water temperature gauge

Oil pressure gauge

Oil temperature gauge (optional)

Battery charging ammeter

A. PREAMBLE TO BILL OF QUANTITIES

1. All equipment and materials shall be new and of the highest standard/quality. All components of the Generator system should be from the same make / manufacturer.
2. Under this lump sum contract the Contractor shall be required to supply/install everything necessary to provide a complete operational system as per contract documents,, specifications and drawings including coordination costs with General and Specialists Sub-Contractors.
3. The description of items in the BOQ are indicative and brief and should be read in conjunction with all the requirements of the tender documents, specifications and drawings. However a complete job is to be carried out by the contractor under this contract.
4. The Tenderer shall submit with his bid Catalogues / Brochures of equipment and accessories offered.

B. Important Notes:

1. The bidder is required to visit the site to familiarize him self about scope of works, before quoting his prices.
2. The electrical installations shall be suitable for 400/230V 3/1 phase 5-Hz supply as required (except otherwise stated). And conforms to requirements of local Electrical authorities and IEE regulations. The electrical installations shall be completed in all respect. It is Contractor's responsibility to obtain approval of electrical installations from Electric Inspector, Government of Sindh.
3. All conductive but non current carrying parts of electrical installations shall be earthed properly.
4. Cables / wires color codes for different phases, neutral, earth should be followed and load balancing shall be achieved.
5. The routing and height of cable tray / trunking shall be as directed by Architect / Consultants.
6. Mechanical ventilation shall be provided in LT and synch panels.
7. Electrical works to be coordinated with other services.
8. Submit samples of materials or its technical submittals to Consultant for approval before manufacturing / installation.
9. Submit 3 sets of shop drawing and as built drawings (hard & softcopies) to Consultant for approval before manufacturing / installation or more copies or more information if mentioned else where in the tender documents.
10. Consultants / Client's Engineer should be invited for inspection of equipment / material without any extra cost to clients, prior to its delivery to site.
11. Any material, if not found in accordance with tender / contract drawings / BOQ / specification during or after installation(s), even in use and paid for, shall be replaced by contractor, at no extra cost to client. Any delay in such replacement shall be chargeable by client appropriately from contractor.
12. All material shall be new, latest in technology and latest manufactured from the manufacturer's line of production. Old models if used shall not be acceptable and shall be replaced by contractor at their own cost & risk. Any payment made in respect of un-proper work not satisfactory in view of Consultants and clients) shall be liable for accounts adjustment and refunded to Clients, if demanded so by Consultant / Clients.
13. GST & other taxes should be included in the prices.

ELEVATORS & DUMB WAITERS

1. APPLICABLE CODES AND STANDARDS

The standards and codes applicable to only a portion of the works specified in this section are referred in the relevant clauses of this section. The works shall generally conform to standards & codes (latest additions) listed hereunder:

British Standards Specification (BS)

B.S. 5655 : Safety rules for construction and installation of electric lifts
EN 81 : Parts 1, 5, 6 & 8 with Appendices

American Welding Society (AWS)

AWS B 3.0 : Standard Qualification Procedure
D 1.1 : Structural Welding Code

National Electric Manufacturer's Associates (NEMA)

NEMA-1CS6 : Enclosures for Industrial Controls and System

National Electric Code (NEC) by NFPA

NFPA.70 : National Electric Code
ANSI-A 17.1 : American National Standard Institute
"Safety Codes for Elevators & Dumbwaiter"

Other authoritative codes and standards which ensure equal or higher quality than those referenced may also be acceptable subject to approval of the Engineer.

Any conflict between the requirements of this specification and those on the figures herein or in the codes, standards and specification referred to herein shall be brought to the attention of the Engineer for resolution whose decision will final and binding.

1.1 Acceptable Manufacturers

Fully imported lifts are to be provided, subject to compliance with requirements, products of one of the following manufacturers are to be provided:

Origin of lift Manufacturing Company shall be of North American, West European region or Japan.

1.2 Origin of Supply

Complete equipments shall be imported origin and provided by the single source of lift manufacturer, supplied under the contract agreement.

2. HANDLING & STORAGE

The Contractor shall carry out port clearance, arrange inland transportation and deliver at site the lift machinery/equipment in their original packages and bundles bearing identification tags. A dry and protected area, close to work site, will be assigned to the Contractor for storage of his materials and tools. The Contractor shall store the equipment at his own cost and arrange guards to ensure safety of equipment.

3. PAINTING

3.1 General

All lift equipment including exposed steel work, ferrous metal parts of motor room equipment, gear and controllers, structures, cars, doors, guide rail fixings and other materials in the hoistway (except guide rails) shall be properly prepared, primed, undercoated and then painted in

accordance with recognized international standards. The type and shade of paints particularly the finished shall be subject to the approval of the Engineer's.

3.2 Preparation of metal surfaces prior to painting

Before application of primer, all surfaces shall be made clean and free from rust and grit by means of blast cleaning. Automatic blasting may be used with most of the common abrasives such as shot, chilled iron, cut wire, or proprietary grit abrasives. The surfaces shall be immediately painted after blast cleaning. In the event the surfaces become otherwise contaminated in the interval between cleaning and painting, re-cleaning shall be done before painting.

Surfaces of stainless steel, aluminum, bronze and machined surfaces adjacent to metal work being cleaned or painted shall be protected by effective masking or other suitable means, during the cleaning and painting operations.

3.3 Application of Paints

All paints shall be in a thoroughly mixed condition at the time of application. All work shall be done in a workmanlike manner, leaving the finished surface free from drips, ridges, waves, laps and brush marks. All paints shall be applied under dry and dust free conditions. Unless approved by the Engineer paint shall not be applied when the temperature of the metal or the surrounding air is below 45 °F Surfaces shall be free from moisture at the time of painting.

The first coat of paint shall be applied immediately after cleaning. When paint is applied by spraying, suitable measures shall be taken to prevent segregation of the paint in the container during painting operation. Effective means shall be adopted for removing all free oil and moisture from the air supply lines of the spraying equipment.

Each coat of the paint shall be allowed to dry or harden thoroughly before the succeeding coat is applied. Surfaces to be painted that will be inaccessible after assembly shall be completely painted prior to assembly operation.

4. MATERIALS & WORKSHOP

4.1 Materials

All materials shall be of the highest grade, free from defects and imperfections, of recent manufacture and unused, and of the classification and grades designed, conforming to the requirements of the latest issue of the appropriate specifications and standards. All materials, suppliers and articles not fabricated by the Manufacturer shall be the products of recognized reputable manufacturers.

4.2 Workmanship

All work shall be performed and completed in a thorough workmanlike manner and shall follow the best modern practice in the manufacturer of high-grade machinery, notwithstanding any omissions from the Bid Documents. All work shall be performed by mechanics skilled in their various trades. All parts shall be made accurately to American Standard or other approved gage, where possible, so as to facilitate replacement and repairs. All bolts, nuts, screw, rivets, threads, pipes, gages and gears shall conform to applicable American or other approved standards.

4.3 Structural Metal Work

The fabrication of the Structural Steel shall be performed strictly in accordance with these specifications and shall otherwise conform to the latest revision of the American Institute of Steel Construction "Specification for the Design Fabrication, and Erection of Structural Steel for Buildings". Surface finish shall conform to ANSI Standard B 64.1 Surface Textures. The Manufacturer shall be responsible for all errors of fabrication and for the correct fitting of the elements of the equipment. Structural Steel shall be thoroughly straightened by methods that will not result in injury. Sharp kinks or bands in members to be straightened will be cause for rejection. Completed work shall be free from kinks, bends or winds. Shearing shall be accurately done, with neat finish. Corners shall be square and true unless otherwise shown on the

Drawings. Re-entrant cuts shall be made in a workmanlike manner and, where they cannot be made by shearing, a re-entrant pinch may be used. Re-entrant cuts shall be filleted unless otherwise approved by the Engineer. Bends, except for minor details, shall be made with approved dies or bending rolls. Where heating is required, precautions shall be taken to avoid overheating the metal, and it shall be allowed to cool in such a manner as not to destroy the original properties of the metal. Steel with welds will not be accepted except where welding is definitely specified, called for on the Drawings, or otherwise approved. Low-carbon structural steel may be cut by machine-guided or hand-guided torches instead of shears or by saws. Flame cutting of material other than low-carbon steel shall be subject to approval and where proposed shall be definitely indicated on detailed drawings submitted to the Engineer. Where a torch is mechanically guided, no chipping or grinding will be required except where necessary to re-move the slag and sharp edges. Flame gouging will be permitted in preparation of welding where a torch is hand-guided. All cuts shall be chipped, ground or machined to sound levels.

5. WORKS DESCRIPTION

Lift shall be installed by the Contractor at locations and in the positions in the lifts wells and machine room shown on the drawing. The respective lift wells and machine room dimensions are also shown on the drawings.

The characteristics detail of the lift to be supplied under this contract are listed. To construct and functional details are given hereunder:

5.1. Lift Car

a). Car Frame & Platform

The car frames, consisting of upper yoke with cross yoke side braces and bottom frame shall be made of welded or bolted steel channel sections, sufficiently rigid to withstand the operation of the safety-gear without permanent deformation of the car frame. The elevator car, platform, door operating mechanism, safety doors, maintenance station etc. shall be mounted on car frame.

The deflection of the members carrying the platform shall not exceed 1/800 of their span under static conditions with the contract load evenly distributed over the platform.

Roller guides, mounted on car frame, shall have individual suspension to cushion jolts and minimize noise and vibration.

The platform shall be of fabricated frame of formed and structural steel shapes gusseted and rigidly welded, with provision for a floor covering as specified with the car body Work. Rubber pads of sufficient size shall be provided between the car frame and the platform to provided sound and vibration isolation. The underside of the platform will be covered with sheet steel to provide adequate fire resistance.

An aluminum sill grooved to suit door spuds shall be fitted to the platform together with a toe-guard.

The car bodywork shall be carries on the platform with the top fixing to the car frame being suitable isolated.

All auxiliary equipment shall be mounted and supported from the car frame.

b). Car Body Work

The car bodywork shall be of steel construction with provision for interchangeability of décor finishes and ceiling designs. The roof shall be constructed to withstand the weight of two men without deformation.

The car top shall have provision for emergency communication and roof trap door with micro-switch. A3 pin socket outlet shall be fitted on top of the lift car, besides two outdoor protected type lights one each at the bottom and top of the car operated through an MCB.

c). Finish

The car enclosure shall have decorative as per technical data sheet. Recessed kick plate 6" high of stainless steel shall be provided on the three walls of the lift car. The floor shall be provided with sheet steel sound-isolated platform with granite flooring unless otherwise specified in technical data sheet.

A6 mm thick full width safety glass mirror will be fitted between the ceiling and half height of the rear wall of the car.

Ceiling shall be of plastic grid removable type with modular light fittings.

Handrails on three walls shall be provided with satin finish standard stainless steel hollow section. Fixing brackets shall also be in stainless steel.

The design and finish of the car interior together with suspended ceiling, light fittings, floor covering and other fittings shall be to the Engineer's approval. The Contractor shall offer various options of car finish with his bid.

d). Telephone

A telephone compartment shall be provided in each car in the front return panel above the car operating buttons. The compartment shall be provided with hinged door flush with the panel. The entire compartment and door shall be of stainless steel.

The Contractor shall also provide a telephone set in the compartment which shall be connected to the machine room. Alternatively, intercom system with speaker set shall be provided.

5.2. Doors

a). Landing Doors

Each landing shall be provided with two panel centre opening doors unless otherwise specified in technical data sheet. The doors, frames and architraves (if applicable) shall be made of stainless steel in satin finish. The door panels shall have a fire resistance rating of at least one hour. The panels shall be interconnected by maintenance – free self-tensioning synchronizing wire rope.

Each landing shall be equipped with a toe-guard apron at the hoistway entrance side. The toe-guard apron shall be of sheet steel not less than 16 gauges thick, and shall extend not less than 50mm beyond the entrance jamb at each side. Toe-guard apron shall be approximately 2 feet deep, adequately fastened and braced, the lower edge turned inward.

The frames shall be of 14 SWG (min.) and panels' fascia, toe-guards, dust and hanger covers shall be of 16 SWG. All other features not covered above shall be similar to that specified under car doors.

Each landing entrance shall be equipped with an approved type factory tested interlock as required by the code. The interlock shall be designed to prevent moving of the car away from the landing until the doors are locked in the closed position as defined by code and shall prevent opening of the doors at any landing from the corridor side unless the car is at rest at that landing or is in the leveling zone and stopping at that landing.

Landing door unlocking device as specified by the ANSI A17.1 or B.S. 5655: part 1 code shall be provided to permit authorized persons to gain access to hoistway when lift car is away from the landing.

Each Landing door or door panel shall be furnished with sheave type two-point suspension hangers and tracks complete in all respects. The sheaves shall have polyurethane tries with ball bearings sealed and lubricated for life. Hangers shall be provided with an adjustable slide to take the up thrust of the doors. Tracks shall be of cold drawn steel shapes with smooth surface and shaped to conform to the hanger sheaves. Tracks shall be removable for replacement.

b). Car Doors

The car doors shall be two panel center-operating types unless otherwise specified in technical data sheet. The door-gear shall be operated by VVVF AC drive. The door gear shall be built-in unit with the car door top track support, mounted on the car entrance column extensions.

Note: Two hours fire rated door for dumb waiter.

A retraceable car door coupling shall be provided to connect the car and landing doors to eliminate any backlash and ensure complete door synchronization.

The car doors, frame and front shall be of stainless steel (satin finish) with panel construction and other features such as fire rating, etc. similar to the landing doors.

The door panels shall be suspended from sheave hangers with polyurethane tries and sheaves running on a polished steel track, and guided at the bottom by non-metallic shoes sliding in an extruded aluminum threshold groove.

If the car is stationary at floor level with the doors closed, it shall be possible to open the car doors from inside the car by pushing the car door in the opening direction. To open the doors from the landings, the triangular key must be used.

c). Door Safety Devices

i). Full Width Light Curtain

The car doors shall be fitted with light barrier system extending from 25mm above floor level upto a height of 1600mm, operating between cars and landing doors. The barrier system shall comprise of a transmitter and a receiver strip containing several pairs of transmitter & receiver generating a large number of invisible light rays. In case if any one of these rays is interrupted, the control unit immediately reverses the door motion. The light curtain shall recalibrate itself at regular interval to update its scanning cycle.

In addition to above the car doors shall be provided with an additional safety such as door closing force limiting device or photoelectric beam etc. to maintain operational safety in case of failure of the main light barrier system.

ii). Door Open Timing Feature

The door operation shall also have door open timing feature operation in conjunction with light rays to provide adjustable, reduced, hold open time once rays are broken and re-established. In the event rays are broken beyond an adjustable time, a buzzer shall sound and doors to close at reduced speed.

The driving mechanism shall be designed such that:

The closing force applied to the doors shall meet the requirements of B.S. 5655: Part I.

The motion of the doors will be reversed if they meet an obstruction. An AC motor with VVVF drive to provide variable speed shall be provided to obtain the performance required by the control system.

Mechanical Control Station, carrying controls and equipment as specified in B.S. 5655 shall be fitted on the top of the operator.

5.3. Mechanical Room Equipment

a). General

i). Arrangement

The hoisting machines over hoist-way shall be placed on steel beams, which shall be provided by the Contractor for placing over concrete foundations as per Engineer's

approval. Anchor bolts, templates, interest, signal boxes, and sleeves for installation shall be furnished by the Contractor.

ii). Identification

Each hoisting machine and corresponding controller shall be numbered with 100mm high numeral giving lift numbers.

iii). Sound Control

Sound reducing buffers of elastic material shall be provided under the base of the hoisting machines to isolate sound and vibrations from the building structure. The rotating parts shall be dynamically balanced to eliminate vibration. The conduit to controller frames, starter frame machinery with flexible connection shall be suitably fastened.

b). Hoisting Machines

i). Gearless Drive

The hoisting machine shall be of the permanent magnet gearless drive with motor, brake and other integral parts mounted as one assembly on steel bed plates so that proper alignment of these parts is maintained under all conditions.

Means shall be provided on all lift machines to enable the lift cars to be raised or lowered in an emergency by manual operation. The direction of winding corresponding to the raising and lowering of the lift car shall be clearly indicated.

Manual operation shall be by a smooth-rimmed detachable, spokeless wheel fitted to the shaft.

ii). Brakes

The brake shall be spring actuated, electrically released and of adequate proportions for the duty involved and fitted with two self-aligning shoes actuated by compression springs.

The brake shall be instantly and automatically applied in the event of interruption of the power supply.

The brake shall be capable of bringing the car to rest smoothly, under maximum conditions of load and speed, and capable of sustaining static load of 150% of the contract load.

iii). Motor

The variable voltage variable frequency (VVVF), motor specially designed to meet all lift duty requirements shall have a duty cycle rating of a minimum of 180 starts per hour. The motor speed shall have controls to allow smooth transition between acceleration and deceleration phase. The motor shall be capable of stable operation at all speeds up to the stated maximum and no abrupt speed change shall be permitted. It shall have a drip proof enclosure and may be force ventilated.

The drive motor shall be rated to provide sufficient power to accelerate the elevator to full speed in the shortest period while maintaining passenger comfort.

The power system shall incorporate solid state equipment controlling the speed of the lift motor. Smooth performance with step less acceleration and deceleration are to be provided with a leveling accuracy of $\pm 0.25"$ and the final stop at floor level is to be achieved dynamically after which the machine brake shall be applied to hold the lift car stationary.

5.4. Hoistway Equipment

a). Suspension Ropes

Suspension ropes of high grade steel, specially designed for lift duty shall be provided in conformity with the requirements of B.S. 329 the material of the rope shall confirm to B.S. 2763. It shall be free from loose wires, distorted strands or other irregularities. All rope terminals shall comply with B.S. 461. Independent adjustment shall be provided for each rope.

The length of each rope shall be so adjusted that it loses traction with sheave when the counter-weight touches its buffers.

An automatic device shall be provided for equalizing the tensions of suspension ropes at least at one of their ends.

b). Guides, Fixing and Inserts

The guides shall consist of high quality 'T' section steel of adequate strength and dimensions suitable for travel, car weight, speed and lift capacity, guiding surfaces shall be accurately machined. The joints shall be spigotted and joined by machined steel finish plates.

Guides shall be of sufficient length to prevent any of the car or counterweight shoes from running off the guides.

All guides are to be securely fixed the walls of the lift well by steel brackets bolted to metal inserts or by other approved means. Rag bolts shall not be permitted. All metal insets, fixings, guide rails, anchor bolts etc. shall be provided by the lift Contractor.

Guides shall be so joined and fixed to their brackets that they do not deflect by more than 3mm under normal operation.

Guides and their fixing shall withstand the application of the safety-gear without permanent deformation when stopping a fully laden car or the counterweight.

c). Counterweight

A counterweight equal in weight to the car plus 40% to 50% of the specified load shall be provided to each lift. Structural Steel frame shall support requisite number of cast iron weights. It shall be fitted with guide shoes and suspension arrangements and accessories suitable for specified lift capacity.

Car and counterweight are to be fitted with roller guide shoes unless otherwise specified in technical data sheet.

d). Safety Gear and Governor

A friction type progressive safety gear actuated by centrifugal over speed governor shall be security bolted to the car frame under the car platform.

The governor wire rope operating the safety gear mechanism shall not be less than 8mm diameter.

The tension weight fitted with an electrical safety device shall be provided to cause the hoist motor to stop should the governor rope break or slacken.

The governor shall be fitted with a direct driven unit to relay to the control system both the speed and position of the lift in shaft.

The governor shall be equipped with two electrical switches, preset to operate progressively in case of over speeding to reduce the lift speed in the first stage and if the lift speed is not brought under control, operate to cut of power supply to the hoist machine and apply brakes.

If the car continues to travel downwards at executive over speed, the mechanical trip shall operate causing the governor jaws to grip the rope to bring the safety fear mechanism into

operation causing the jaws to grip the guide rails equality through self-aligning friction shoes thus bringing the car to rest gradually and smoothly. The governor and safety gear shall be released by raising the car.

The governor and safety gear shall be adjusted to operate as specified by B.S. 5655.

e). Buffers

Oil buffers of spring-return type shall be supplied and installed in pit under car and counterweight for each lift. The minimum total stroke of the buffer shall be based on the retardation of 32 feet/sec.² based on 115% contract speed. The maximum rate of retardation of the oil buffers based on 115% contract speed shall be 80.5 feet/sec.² excluding any transient decelerations having duration not exceeding 0.04 sec.

The buffer shall be fitted with means of ascertaining the correct amount of oil in the buffer.

Each buffer shall be permanently and legibly marked to indicate the type and quality of oil to use within the buffer.

The buffers shall be self-setting type fitted with safety device to ensure its return to their normal position after operation.

f). Final Limit Switches

The lifts shall be equipped with an automatic device arranged to bring the car to stop at the terminal landings independent of the regular operating devices in the car. Final limit switches should stop the car and prevent normal operation should it travel beyond the normal stopping device.

Separate control devices for normal stopping and final limit switches shall conform to the requirements of BS 5655: Part I.

5.5. Controller & Control System

a). Controller

The controller shall be floor mounted, upright type enclosed in enamel finish steel cabinet with either hinged doors at the front and removable panels at back or hinged door both at front and back.

The control system shall be microprocessor based and fitted with all safety devices to protect equipment and motors from damage in the event of overload or other malfunction. Protection against phase reversal shall provide as per code.

The driving unit control module, comprising of power and command module, shall control drive performance parameters. The controller unit shall control acceleration & deceleration, speed and the jerk rates during change in acceleration or deceleration to provided stepless speed variation for maximum passenger comfort. The jerk rates shall be individually adjustable to user's satisfaction. Upon receiving signal to perform journey, the command module shall evolve optimum speed profile for each journey and trigger power module for AC/DC and Dc/AC conversion for necessary drive current and voltage to obtain desired motor torque.

The controller shall control car motion on feedback from motor-mounted tachometer and operate the brakes of hoisting motor through the signals received from micro switches and load weighing devices.

The controller shall be arranged to cut off the power supply, apply the brake and bring the car to rest upon failure of operation of any of the electrical safety devices.

The controller shall meet the requirements as specified in BD 5655.

b). Control System

i). General

The design of control system shall be based on functionally arranged section modules featuring high degree of efficiency, economy of operation, adaptability to changing operating conditions, safety and reliability in operation through maintenance free electronic circuitry.

The control equipment shall be microprocessor based electronic solid state. The total system shall be designed to operate in normal machine room ambient and incorporate full protection against noise and electrical interference generated within the power section, controller and Switchgear. The system design shall allow the control algorithm to be reprogrammed by software changes.

The Controller for each main bank lift shall be capable for individual lift control as well as group control. It shall be state-of-art microprocessor based controller capable of high-speed data transmission and analysis for optimization of traffic control.

All modules shall be tested at the manufacturer's works prior to installation. System component shall be subjected to environmental endurance, thermal shocks and salt spray in test chambers.

The control system for the passenger lifts shall be group Supervisory type as per technical data sheet with provision to operate any lift independently from the group.

ii). Group Supervisory Operational Mode

The operational mode of the Passenger lift shall be group supervisory automatic control with special operation features, viz emergency operation and fireman switch.

The control system shall be provided with a parking feature, which returns the car to the main floor when there are no calls in the system.

The lift shall be provided with individual landing station and operated from interconnected landing buttons including two operating devices in the car. Single touch buttons shall be mounted at each terminal landing.

On touching car or landing buttons, (other than those for landing at which car is standing) shall start the car provided interlock circuits are established and causes car to start traveling in the direction of registered call. Car shall stop at the designated landings for which calls are registered with stops made in order, in which landings are reached, Irrespective of sequence in which calls are registered, provided call for a given landing is registered sufficiently in advance of arrival of car at that landing to permit stop to be made.

If there are no car calls and car starts up in response to outside landing calls, car shall proceed first to the highest down call and then reverses to collect other down calls. Up landing calls shall be collected similarly when car starts down in response to such calls. If car stops for a landing call and a car call is registered within a predetermined interval after.

Stop for a landing corresponding to direction car was traveling; car shall proceed in the same direction regardless of other landing calls registered.

If DOWN landing buttons are touched while car is traveling up, car shall not stop at these landings, but calls remain registered. After highest car and landing calls have been answered and door interlock circuit is established, car shall reverse automatically and respond to down car and landing calls. When traveling down, car shall not respond to up landing calls, but calls shall remain registered and answered on next up trip. No double door operation shall be permitted.

iii). Load weighing

Means shall be provided for weighing passenger load, Control system shall be designed to provide dispatching in advance of normal intervals and to provide landing call by-pass when the car is filled to approximately 80% of full capacity load.

Settings shall be individually adjustable. A buzzer shall be provided to indicate overload in lift.

iv). Door Operation

Doors shall open automatically when a car arrives at a terminal to permit egress of passengers. When another car is at the terminal and is loading for departure or upon expiration of a timed interval, the doors shall close until car is designated for loading. In the event a passenger has entered the elevator, the doors shall reopen upon registration of call on the car button or by pressing the door open button. If no other car is at the terminal, an arriving car shall have its doors open until the car is dispatched or expiration of a timed interval with no demand.

v). Automatic leveling

An automatic 2-way leveling device shall be provided, designed to govern the leveling of the car to within 6mm above or below the landing sill. The leveling operation shall avoid over-travel, under-travel, of the car and maintain the traveling accuracy regardless of the load in the car, direction of travel, rope slippage or stretch in ropes.

vi). Independent Operation

Controls shall be provided for operation of the lift from car buttons only. A key operated switch shall be provided in each car.

vii). Emergency Features

- 1) Emergency operation: The lift shall be equipped with control system to operate and recall the cars in fire or other emerge conditions and to allow the lift to run on emergency power supply.

The operation of the lift on emergency service shall be as follows:

- The lift shall be operable only by a person in the car.
- Lift shall not respond to lift corridor calls.

The opening of power operated doors shall be controlled only by buttons or switches. If the switch or button is released prior to the doors reaching the fully open position, the doors shall automatically re-close. Open doors shall be closed by either the registration of a car call or by "door close" switch or button.

Lift shall be removed from emergency service by moving the emergency service key-operated switch in the car to the 'off' position with the car at the main floor.

- 2) Emergency lighting and Emergency alarm unit: An emergency light shall be included for each lift car. An automatic change over switch shall be provided in the controller so that upon normal supply failure Emergency power supply shall be available for the light fixture, exhaust fan, and alarm unit.

The Contractor shall supply a suitable button in the car control station wired to a terminal box fixed in the lift shaft near the bottom floor served. A suitable alarm bell shall be provided and fixed including all necessary wiring connecting upto the terminal box.

The power for the emergency lighting, exhaust fan and alarm bell shall be from the same emergency supply consisting of rechargeable nickel cadmium battery unit with trickle charger and 10 years minimum life expectancy.

- 3) Emergency power transfer: In the event of normal power failure, adequate emergency power will be supply through Employer furnished stand-by generator to run the lift.
- 4) Intercom: The Contractor shall install for each lift, an intercom facility with control room or at location designed by Employer for 24 hours communication.
- 5) Earthquake control: In the events of an earthquake, the lift facility shall be provided with a seismic detector which will bring all cars to stop at the next floor and open the doors.

5.6. Signals & Features

a). Integrated Hall Indicator

An integrated hall indicator consisting of digital car position indicator (revealing floor position of car) and illuminated arrows indicating the arrival and departing direction, as determined by the control system shall be installed above each individual lift and at each landing. A two tone electronic going shall also be provided for audible announcement of the arrival of the lift car.

The digital car position indicator shall be either of 2 character 7/8 segment type with character height of 35-40mm.

The direction arrows shall be of acrylic and protrude from the faceplate for lateral visibility.

The integrated hall indicator shall be of horizontal configuration. The stainless steel face plate, min 2mm thick, of satin finish containing the digital car position indicator and direction arrows. The hall indicator shall operate on 24 V.D.C. Supply.

b). Landing Call Station

Landing call station fitted with call buttons shall be installed at each landing. It shall be designed for mounting on the landing door frame or on adjacent side wall, subject to Engineers' approval.

The call buttons shall be of micro-movement type, constructed of stainless steel pressel suitable for long arduous duty. The translucent surround of the button shall illuminate to indicate acceptance of call signal. The pressel shall incorporate two light emitting diodes. The pressels shall be mounted flush with the faceplate. The faceplate shall be of stainless steel 2mm thick, fixed with tamper resistant screw.

The call buttons of each landing station shall be inter-linked such that with the pressing of call button of any lift, call button of lifts in the same direction shall light up and record the call.

c). Car Station

The car station shall be integral with the front return of the car and constructed from 1.6mm thick stainless steel, plate of natural satin finish.

The hinged full height front panel of the car station shall carry the controls and indicators. The panel shall be fitted with a secret release, which can only be opened from the back of the trough. When the hinged panel is opened an isolate/normal switch shall be available.

The car-operating panel shall contain atleast the following controls:

- Alarm button.
- One floor button for each floor served.
- Open door button/hold on button.
- Key operated car independent service switch.
- Digital car position indicator and direction arrows.

All buttons shall set flush with the panel surface for maximum resistance against abuse. When operated, a LED illuminated halo shall surround the buttons thereby informing that the

call has been registered. The buttons shall be plastic pressel engraved with the appropriate floor marking.

The digital car position indicator and direction arrows shall be positioned above the buttons.

5.7. Power Supply & Electrical Installation

a). General

The power supply at load break switch will be available in the lift machine room. All further wiring, controls and providing proper distribution boards, alongwith necessary material and accessories beyond the power supply points shall be supplied and installed by the Contractor. The electrical installation and appliances shall comply with BS 5655. Part I.

b). Wiring Installation

All wiring shall be carried out in accordance with the IEE regulation, NEC standard and B.S.S. wherever applicable.

All cables shall be PVC insulated, and if required PVC sheathed also, single or multicore having tinned copper conductors. Cables for different voltage circuits which are run together must have the insulation rating, suitable for the highest voltage present.

Wherever cables are subjected to high temperature such as termination to car light, it shall be protected by suitable heat resistant sleeve. At all terminations, cable ends shall have numbered ferrule to match with the mark on respective component and control drawings. All wiring shall be continuous between terminations.

Traveling cables between the lift well and lift car terminal boxes shall be suspended by looping over reels or by suitable clamps. The connections in the terminal boxes shall be marked for identification purposes.

Traveling flexible cables shall be fire resistant and shall comply with B.S. 6977:

c). Trunking and Conduits

All wiring from machine room to motor controls at each floor and to other circuits shall either be run in 16 SWG galvanized steel conduit or trunking, the selection and route of which shall depend on the number of cables and ease of installation and maintenance. If trunking is installed it shall have removable covers, and the trunking finished in dark grey enamel as per B.S. 381C. Fixing arrangements of conduit or trunking shall be vibration proof suitable for the existing conditions. All connections from trunking or conduits to motors or other equipment subjected to vibration shall be with flexible galvanized steel conduit. All trunking and conduit shall be continuous throughout the length to ensure good earth continuity.

d). Earthing

Earthing of all equipment and metal work which can be subjected to dangerous voltage under normal operating and fault conditions shall be earthed in accordance with NEC Standard. One PVC insulated earth conductor of suitable size having yellow color with green tracer shall be run along the trunking or conduit as main earth. All branch circuits in conduit or trunking and other metal work shall have branch earthing cable connected to main earth. All length of trunking shall also be bonded to main earth.

e). Testing

Testing of electrical installations shall be carried out to the satisfaction of the Engineer in accordance with standard practice and recognized international standards/codes.

5.8. Location Materials

a). Pit Access Ladder

Rugged steel ladders for easy access to the pits shall be provided by the lift Contractor in all pits.

b). Pit Screen

A suitable rigid steel screen shall be provided and fixed by the lift Contractor at the bottom of the lift well where the counter-weight comes down on its buffers and between lifts. The screen shall have a minimum height of 7 ft. as per code requirements.

c). Separator Beams & Well Trimming Girders

Property designed separator beams and trimming girders shall be supplied and installed at proper location in lift well by the lift contractor to suit fixing requirement of offered lift. To separator beams and trimming girders installed in lift shall be of at least 200mm rolled beams of prime quality structural steel (ASTM A-36 or equivalent).

d). Trap Door

The Contractor shall provide and install the trap doors of rugged construction in the machine rooms at location shown on relevant drawing to enable access of the hoisting machinery into the machine rooms. The trap door shall be strong enough to temporarily withstand/support heavy machinery. It shall be installed flush with the finished floor when closed and lockable only from inside the machine room.

The Contractor shall include the above items in his bid price for the lifts.

6. TECHNICAL DATA

Passenger Lifts

S. No.	Description	Required			
01	Capacity	800 Kg			
02	Travel Height	As per site.			
03	No. of Stops/Openings:				
	Building A			Building B	
	Passenger Lift 1	27	Passenger Lift 1	13	
	Passenger Lift 2	27	Passenger Lift 2	13	
	Passenger Lift 3	27	Passenger Lift 3	13	
	Passenger Lift 4	27	Passenger Lift 4	13	
	Passenger Lift 6	02	Passenger Lift 6	02	
	Cargo Lift 5	27	Cargo Lift 5	13	
	Dumb waiter	02			
04	Lift Speed:				
	Passenger Lift	1.5 m/sec (or as per international standards)			
	Dumb Waiter	0.5 m/sec			
05	Internal Car Sizes	As per existing shaft.			
06	Machine Type	VVVF Motor, gearless drive			
07	Car & Counterweight Guide Shoes	Roller guide shoes			
08	Control System	Triplex Collective Selective/ Microprocessor for elevators. Simplex Selective/ Microprocessor for cargo lift & dumb waiter..			
09	Architraves	Full width of Stainless Steel Natural Satin Finish			
10	Shaft Size	As per Site.			

S. No.	Description	Required
11	Pit Depth	As per Existing
12	Head Room	As per Existing
13	Buffers	Oil Buffers of Spring Return Type
14	Door Size	900mm W x 2100 mm H
15	Door Operating & Type	2 panels centre opening, with VVVF door drive, with door edge safety device, stainless steel construction and satin finish.
16	Indicators	<ul style="list-style-type: none"> - Digital car position indicator on each landing with direction arrows. - Digital position indicator inside car with direction arrows. - Two tone electronic gong announcing arrival of car.
17	Landing Call Station	<ul style="list-style-type: none"> - Raised, micro-movement button with call acceptance illuminated indicators
18	Car Station	<ul style="list-style-type: none"> - Integral with the front return of the car and completed of stainless steel. - It shall include alarm buttons, floor call button, door open/hold button, key-operated attendant switch, fan switch.
19	Car Design	<ul style="list-style-type: none"> - Side and rear walls of stainless steel (satin finish) construction with decorative design. - Front return and car door of stainless steel (satin finish) construction. - Ceiling grid with modular light fittings. - Split AC and Fan/Blower - Stainless Steel Handrails on three sides (Shop Drawings to be provided). - Full width and half height mirror at rear wall (minimum 6mm thickness, European make). - Flooring should be granite as per architect. - Hand set free telephone/intercom system. - Emergency exit. - Load measuring device with overload buzzer and inter-lock till overload is removed.
20	Door Safety Devices	<ul style="list-style-type: none"> - 3D Full height Light curtain protection. - Door opening timing features.
21	Special Features	<ul style="list-style-type: none"> - Attendant control. - Emergency operation and fireman switch. - Emergency lighting & alarm unit. - Earthquake control system. - Emergency Rescue Device (when power failure) - Push button and access card control system for lift operation as per building management. - Auto-parking of lifts, cargo lift and dumb waiters, - Full load no stop. - Fault record - Car emergency exit (trap door in car roof) - Over load device. - Voice guidance system. - Suitability for 40° C ambient temperature - Phase reversal failure indication & interlock - Emergency Landing Device - Hoist Door unlocking device - Overspeed governor. - Provide safety devices to bring car to a safe stop should the lift overspeed in the downwards directions.

S. No.	Description	Required
		<ul style="list-style-type: none"> - Terminal limit switch. - Final limit switch. - Door deterrent device. - Moulded case Circuit Breaker to protect the lift control equipment from unusual voltage surges in the building power supply. - Other interface such as: <ul style="list-style-type: none"> • Remote control interface- parking shutdown • Remote monitor interface-4 dry contracts • video cable in car * remote monitoring system • auto cable in car • RS485 interface
22	Power Supply	<ul style="list-style-type: none"> - 3 Phase / 380V / 50 Hz. - 1 Phase / 220 / 50 Hz. (for lighting) normal alongwith ½ hour UPS power backup. - Emergency Car Light

7. INSTALLATION

7.1. General

The installation of lift equipment including its electrical installations shall comply with applicable standards, manufacturers' instructions and recommendations. Electrical work required during installation shall comply with NFPA 70 or approved equivalent.

The scope of installation and civil works shall include the following:

- Providing and/or cutting all necessary holes, chases and openings and making good after installation of equipment.
- Supplying and fixing all supports, beams, ladders etc. necessary for the installation of the machinery, guide brackets, doors, buffers etc.
- Furnishing all necessary cement and/or concrete for 'grouting-in' brackets, bolts etc.
- Providing and fixing suitable scaffolding and protection of work in progress.

7.2. Welded Construction

Welded construction shall be provided for installation of Lifts wherever bolted connections are not required for subsequent removal or for normal operation, adjustment, inspection, maintenance or replacement of worn parts. Welding workmanship and qualification of welding operators shall comply with American Welding Society (AWS) standards or approved equivalent.

7.3. Sound Isolation

Rotating and vibrating Lift equipment and components shall be mounted on vibration absorption mounts designed to effectively prevent the transmission of vibrations of the structure, and thereby eliminate the sources of structure - borne noise.

7.4. Lubrication

Operating parts of the system including ropes, guides, etc., shall be lubricated as per manufacturer's recommendation.

7.5. Alignment

Proper co-ordination of installation of Hoistway entrances with the installation of elevators' guide rails shall be done for accurate alignment of entrances. Wherever possible the final adjustment of

sills and doors shall be delayed until the car is operable in the shaft. The clearance shall be reduced to minimum, safe, workable dimensions at each landing.

7.6. Sills

Sill unit shall be set at each floor landing accurately aligned, slightly above structural floor, to suit level of scheduled floor finish.

7.7. Painting, Retouching & Re-finishing

After completion of installation and testing to the satisfaction of the Engineer-in- Charge, the Contractor shall carryout all finishing, retouching and refinishing operation on the entire equipment accessories and installation matching the original finish in an approved way. All auxiliary works carried out by the standard after applying anticorrosive base.

8. TESTING AND INSPECTION REQUIREMENTS

The Contractor shall submit separate list of shop tests, to be conducted prior to shipment and field test after installation prior to commissioning.

Testing after installation shall be carried out for each lift before it is put into normal service in accordance with B.S. 5655 Part 10 and appropriate certificate shall be completed. The tests shall include but not limited to the following:

- Functioning of all system and devices
- Operational test of all safeties
- Protection against false signals
- Earth fault test on cable/controller & switch gears
- Insulation resistance test for cables

A thorough inspection of all equipment shall also be under taken at this stage and appropriate certificate shall be completed.

Lift shall be periodically re-examined during defect liability period and at the end of guarantee/defect liability period appropriate certificate shall be completed to assess operational performance.

All equipment and personnel required to complete testing and inspection shall provided by the Contractor. All erection work and test shall be performed by the Contractor's erectors who shall be suitable qualified and experienced persons to the satisfaction of the Engineer.

LIGHTNING PROTECTION SYSTEMS (LPS)

1. GENERAL

This Section specifies the lightning protection system for the building(s) or structure(s). This system provides safety for the building and occupants by preventing damage to the structure caused by lightning. The design of this system is to be in strict accordance with this section of the specification and all contract drawings that apply.

The work covered under this section of the specifications consists of furnishing labor, materials and services required for the completion of a functional and unobtrusive lightning protection system approved by the architect and engineer.

A firm actively engaged in the installation of certified lightning protection systems.

2. SYSTEM DESCRIPTION

The entire lightning protection system shall be designed and installed in accordance with:

- a) National Fire Protection Assoc. (NFPA) Document # 780
- b) Underwriters' Laboratories, Inc. (UL) Standard # 96A
- c) Lightning Protection Institute (LPI) Standard # 175
- d) The system should be free from radioactive material.

3. SUBMITTALS

A complete shop drawing shall be submitted to the architect and engineer for approval prior to commencement of the installation. The shop drawing will show the extent of the system layout designed for the structure along with details of the products to be used in the installation. The drawing will include the stamp of the LPI Master Installer responsible for the system design.

4. QUALITY ASSURANCE

- a) The contractor shall furnish an LPI Master Installation Certificate or a Limited Scope report upon completion of the installation.
- b) The system installation shall be made under the specialist Installer.

5. PRODUCTS

All materials shall comply in weight, size, and composition with the requirements of a nationally recognized testing laboratory. All equipment shall be properly listed and labeled. The system furnished under this specification shall be the standard product of a manufacturer regularly engaged in the production of lightning protection equipment and a member of LPI. Equipment shall be the manufacturer's latest approved design of construction to suit the application where it is to be used in accordance with accepted industry standards and with NFPA, LPI, & UL requirements.

6. MATERIALS

- a) Class I materials shall be used for systems on structures not exceeding 75 feet in height and Class II materials shall be used for systems on structures exceeding 75 feet above grade.
- b) Copper shall be of the grade ordinarily required for commercial electrical work, generally designated as being 95 percent conductive when annealed. Aluminum conductors shall be of electrical grade aluminum.
- c) Lightning protection materials shall be coordinated with building construction materials to assure compatibility. Aluminum lightning protection materials shall not be embedded in concrete or masonry, installed on or below copper surfaces, or used where contact with the earth is possible terminating 18" above grade level minimum. Copper lightning protection materials shall not be installed on aluminum surfaces. Copper system components within 2 feet of chimney exhausts shall be tin coated to protect against deterioration.

- d) Strike termination devices shall be provided to place the entire structure under a zone of protection as defined by the Standards. Air terminals shall project a minimum of 10 inches above protected areas or objects. Air terminals shall be located within 2 feet of exposed corners and roof edges.
- e) Metallic bodies having a thickness 3/16" or greater may serve as strike termination devices without the addition of air terminals. These bodies shall be made a part of the lightning protection system by connection(s) according to the Standards using main size conductors and bonding fittings with 3 square inches of surface contact area.
- f) Cable conductors shall provide a two-way path from strike termination devices horizontally and downward to connections with the ground system. Cable conductors shall be free of excessive splices and sharp bends. No bend of a conductor shall form a final included angle of less than neither 90 degrees nor have a radius of bend less than 8 inches. Structural elements and design features shall be used whenever possible to minimize the visual impact of exposed conductors.
- g) Cable down conductors may be concealed within the building construction or enclosed within PVC conduit from roof to grade level. Down conductors shall be spaced at intervals averaging not more than 100 feet around the protected perimeter of the structure. In no case shall any structure have fewer than two down conductors. Where down conductors exposed to environmental hazards at grade level, guards are shall be used to protect the conductor to a point 6 feet above grade.
- h) In the case of structural steel frame construction, cable down conductors may be omitted and roof conductors shall be connected to the structural steel frame at intervals averaging not more than 100 feet around the protected perimeter of the structure.
- i) Exposed cable conductors shall be secured to the structure at intervals not exceeding 3 feet – 0 inches. Fasteners, nails, screws, or bolts shall be of suitable configuration for the intended application and of the same material as the conductor or of electrolytic ally compatible materials. Galvanized or plated steels are not acceptable.
- j) Connectors and splicers shall be of suitable configuration and type for the intended application and of the same material as the conductors or of electrolytic ally compatible materials.
- k) Ground terminations suitable for the soil conditions shall be provided for each down lead conductor. Where the structural steel framework is utilized as main conductors for the system, perimeter columns shall be connected to the grounding system at intervals averaging 60 feet or less on the protected perimeter. For any structure in excess of 60 ft. in vertical elevation above grade, a ground loop interconnecting all ground terminals and other building grounded systems shall be provided.
- l) Common interconnection of all grounded systems within the building shall be accomplished using main size conductors and fittings. Grounded metal bodies located within the calculated bonding distance as determined by the formulas of the Standards shall be bonded to the system using properly sized bonding conductors.
- m) Surge suppression shall be provided at every system entrance to the structure to prevent massive lightning over voltages from entering the structure. Additional surge protection for internal electronic equipment may be determined through cost-benefit analysis by a trained engineer.

7. EXECUTION

The installation shall comply with the requirements of NFPA 780, UL 96A, and LPI 175. The installing contractor company shall be listed with the Lightning Protection Institute. The installation contractor shall have personnel on staff Certified by the LPI as a Master Installer or Master Installer – Designer of lightning protection systems. LPI qualified staff shall provide supervision of the installation to the Standards.

8. INSTALLATION

- a) The installation of the lightning protection system components shall be done in a neat and workmanlike manner.
- b) Roof penetrations required for down conductors or for connections to structural steel framework shall be made using through-roof assemblies with solid rods and appropriate roof flashings. The roofing contractor shall furnish the methods and materials required at roofing penetrations of the lightning protection components and any additional roofing materials or preparations required by the roofing manufacturer for lightning conductor runs to assure compatibility with the warranty for the roof.

(Note: The roofing contractor will be responsible for sealing and flashing all lightning protection roof penetrations as per the roof manufacturer's recommendations. The lightning protection roof penetrations and/or method of conductor attachment should be addressed in the roofing section of the specifications.)

- c) LPI certification requires a signature by a representative of the owner for two stages of the installation – the concealed in-ground system and the exposed or roof level area at completion. LPI certification also requires photo documentation of the in-ground system and concealed portions of the installation. LPI certification requires inspection by their third-party field staff after completion of the installation. Upon completion of the lightning protection installation, the installing contractor shall provide to the owner an as-built drawing of the system, along with copies of the LPI Certificates of completion.
- d) If the protected structure is an addition to or is attached to an existing structure that does not have a lightning protection system, the contractor shall certify that the system installed complies with the requirements of the Standards, and advise the owner of the lightning protection work required on the existing structure to obtain full certification for the structure. If the existing structure does have a lightning protection system, the contractor shall advise the owner of any additional work required on the existing system to bring it into compliance with current Standards and thus qualify for LPI certification.

HVAC

A). DUCTING

1. LOW VELOCITY LOW/MEDIUM PRESSURE SHEET METAL DUCTING

All sheet metal work for various air systems shall be furnished, installed, complete, connected, tested and adjusted.

The Contractor shall make shop drawings of all ductwork and the same shall include details of all splitters, takeoffs, vanes, dampers, elbows and all other necessary fittings required for the proper operation of the air systems. Shop drawings and other details shall be submitted to the Consultant for approval before fabrication.

Exact dimensions and location of diffusers, registers, grilles and louvers shall be submitted to the Consultant for approval, otherwise and changes directed after installation shall be made by the Contractor without any additional cost to the Employer. For diffusers and registers adequate provision shall be made in the neck connections for installation of deflectors and dampers.

All duct opening, diffusers, register and grill necks / boxes must be tightly closed during construction to keep out rubbish.

All ducts passing through walls shall have 20 gauge G.I. sheet sleeves extending 6mm beyond the finished face of the wall on both sides. The sleeves shall be of sufficient size to cover duct insulation or any other duct covering and allow at least 90mm clearance in the sleeve for free movement of the finished ducting. The clearance shall be filled with fiberglass pads or other approved material at firewalls and similar locations. The Contractor shall be responsible for supplying, location and setting of all necessary duct sleeves.

All sheet metal ductwork shall be fabricated from commercial quality prime finish galvanizes steel sheet. The specifications for USA and Canadian sources shall be base steel sheet according to 525-64T, 1.25 oz./sq.ft. And for all other sources base steel sheets cold rolled B.S. 1449: Part 1B: 1962 and Zinc coating according to B.S. 2989:1958 Class D, 1.25 oz/sq.ft The zinc coating should be applied uniformly by continuous hot dip method to both sides of the base metal so that the sheet metal can be drawn, formed, lock-seamed and spun without danger of flaking or peeling off the zinc coating.

All un-insulated duct should be cross-broken. Insulated duct not to be cross-broken.

All ducting shall be substantially built with approved joints and seams shall be made smooth on the inside and neat on the outside. The duct joints shall be made as air tight as possible. The laps shall be made in the direction of airflow and no flanges shall project inside the ducting.

Ducts, the width of the greater dimension of which exceeds 30 inch shall be constructed of not more than four feet sections. Ducts, the width of the greater dimension of which is 30" or less shall be constructed of the more than eight feet sections.

All elbows shall preferably be full radius type. If space does not permit, square elbows may be used with double thickness shop fabricated turning vanes riveted with the ducting. Due to space limitation curved elbows with less than a full radius bend may also be used provided single thickness turning vanes are installed in the elbow. Full radius elbows of widths 40"-60" shall have one and over 60" shall have tow single thickness turning vanes. Minimum throat radius of any curved or square elbow shall be 3 inches.

Wherever necessary in duct work, casing or sheet metal partitions, suitable access door and frames shall be provided to permit inspection, operation and maintenance of valves, controls, fire dampers, filters, bearings, traps or other apparatus concealed behind the sheet metal work. Access door shall be provided at distance not exceeding 23m for duct cleaning. All such doors shall be of double construction, of not less than 20 gauge G.I. Sheet metal and shall have sponge rubber gasket around the entire perimeter to make the joint airtight. They shall be hung on heavy flat hinges and shall be secured in the closed position by means of wing type catches. In no case shall access to any of the items of equipment requiring inspection, adjustment or

servicing require the removal of nuts, bolts, screws, wedges or any other screwed or loose device.

The supply and return air duct connection with the fans and equipment shall be made through heavy duty air tight pre-fabricated flexible duct connector to prevent transmission of vibrations. The flexible duct connector will have 75mm 24g G.I. Sheet, 150mm of fabric and 75mm 24g G.I. Sheet. The fabric shall be fixed with G.I. sheet with double-lock grip. The fabric shall be non-combustible heavy glass fabric double coated with fire retardant neoprene to become fully water proof and air tight of approx. 30oz weight sq.yd. The flexible connector shall be Duro-Dyne Supper Metal Fab or approved equal.

The duct shall be adequately supported from hangers firmly fixed and generally suspended from the building structure with the help of concrete inserts, rawl bolts or shooting bolts. The hangers and supports shall not pierce the insulation, which shall be suitably protected and reinforced, at that location. The bottom support shall be 30x6mm M.S. flat or 25x3mm angle for duct up to 12" which, 30x3mm angel up to 30" width, 40x3mm angle up to 72" width and 50x5mm angle up to 96" width. Hangers shall be spaced on average 3-meter centers with a hanger no further than 300mm on each side of any changes of direction. Ducting passing through building expansion joints shall be supported on either side of joint. The hangers for horizontal duct shall be 9mm round rods for duct up to 30" width, 12mm round rods or 40x3mm M.S. flat upto 72" width and 40x5mm M.S. flat upto 96" width. The vertical duct shall be supported at each floor with MS flat straps riveted with the duct. Perforated band or wire shall not be used in any case for supporting the ducts.

The low pressure ducting with static pressure up to 50mm wg and velocities up to 10mps, shall be fabricated according to the following schedule:

Rectangular Ducting

To 8"	larger	dimension	26 gauge (all four sides)
9"-27"	larger	dimension	24 " "
28"-51"	"	"	22 " "
52"-81"	"	"	20 " "
Above 81"	"	"	18 " "

The ducts shall be fabricated with following type of joints or as approved:

i). Longitudinal

Pittsburgh lock, double seam, or grooved seam.

ii). Circumferential (all four sides):

Duct larger dimension

To 23"	Drive slip
24" – 42"	1" high pocket lock or standing seam
24" – 42"	1 ½" high pocket lock or standing seam
24" – 42"	1 ½" high reinforced pocket lock or standing seam.

The bracing for ducting shall be as follows:

Duct larger dimension	Size of bracing MS angle
To 23"	None
24" – 30"	Joints 4' centers without bracing Or joints at 8' centers with 25x25x3mm bracing between joints.
31" – 42"	25x25x3mm bracing @ 4ft centers
43" – 72"	40x40x3mm " @ 4 "
73" – 84"	40x40x3mm " @ 2 "
85" – 96"	40x40x5mm " @ 2 "

The 2' centers bracing would be located at joints and between joints.

The bracing shall be carried around all four sides, bracing angle frame welded at 4 corners and riveted with the duct at maximum 150mm centers.

Special joints, bracing and hangers as specified by the Consultant shall be used for duct with larger dimension over 96".

The medium pressure ducting with static pressure upto 150mm wg and velocities upto 15mps, shall be fabricated according to the following schedule:

Rectangular Ducting

To 18"	larger	dimension	24 gauge (all four sides)
19"-18"	larger	dimension	22 " "
46"-69"	"	"	20 " "
Above 69"	"	"	18 " "

The ducts shall be fabricated with following type of joints or as approved:

(a) Longitudinal

Pittsburgh lock, double seam, or grooved seam.

(b) Circumferential (all four sides):

Duct larger dimension

To 18"	1" high pocket lock, standing seam or bar slip.
19" – 36"	1 ½" high pocket lock or standing seam.
37" – 48"	Reinforced standing seam with 40x40x3mm angle Or 32x32x3mm companion angle flanged joint.
49" – 60"	40x40x3mm companion angle-flanged joint.
61" – 84"	40x40x3mm companion angle-flanged joint.

The companion angle flanged joints shall have neoprene gasket to make the joint air tight

The bracing for ducting shall be as follows:

Duct larger dimension	Size of bracing MS angle
To 12"	None
13" – 24"	25x25x3mm bracing between joints
25" – 42"	32x32x3mm bracing @ 2ft centers
37" – 48"	40x40x3mm " @ 2 "
49" – 60"	50x50x3mm " @ 2 "
61" – 84"	75x75x5mm " @ 2 "

The 2' centers bracing would be located at joints and between joints.

The bracing shall be carried around all four sides, bracing angle frame welded at 4 corners and riveted with the duct at maximum 150mm centers.

Special joints, bracing and hangers as specified by the Consultant shall be used for duct with larger dimension over 84".

The ducting and air dampers shall be furnished to comply with these specifications and latest edition of SMACNA Duct Construction Standards. Where there is a conflict between the two, these specifications will prevail.

B). DUCT INSULATION

1. DUCT THERMAL INSULATION

No insulation shall be applied to any duct work, or to any surface, until all foreign matter has been removed from the surfaces to be insulated. All insulation shall be applied in a manner consistent with good practice and methods.

Insulation shall be continuous through floors, walls, partitions, etc., except when otherwise indicated or specified. Where space will not permit application of insulation in wall or slab chase, the chase shall be packed full of 85% magnesia mineral wool, or fibre glass and protected with cover plates, as approved by the Project Manager.

Ducts shall be insulated as specified in the schedule of equipment and materials.

The thermal conductivity at 24° C of fiberglass insulation shall not be over 0.039 Btu.inch./sq.ft.°F.hour.

For cold air ducts, fiberglass insulation shall have vapour barrier of aluminum foil with internal Fiberglass yarn reinforcement at maximum 25 mm centers, fixed with approved quality adhesive. Care will be exercised that vapour barrier is not damaged / pierced during installation, and any damage will be repaired with the same quality of vapour barrier.

The insulation shall be firmly fixed on the ducting / plenums with approved quality adhesive compound recommended by the insulation manufacturer. Adhesive to be approved by Project Manager. The adhesive shall cover at least 25% duct area on the sides and top and 50% area on the bottom. All circumferential and longitudinal joints shall be lapped at least 50 mm and fully sealed with adhesives. Where rectangular ducts are 600 mm in width or greater the insulation shall be further mechanically secured to the ducts, and at least 25 mm wide metal bands shall be applied at the corners so that the mechanical fastener does not pierce the insulation and vapour barrier.

The insulation shall be applied to the full length of the ducts, including portions where internal sound absorber liner etc. are fixed.

All access doors and removable panels shall be insulated and jacketed separately. The insulation jacket ends on the duct and door or panel shall be sealed with 50 mm wide PVC vapour seal self-adhesive type tape to prevent damage to the insulation due to use and servicing. All cold air duct in the conditioned space shall be insulated with 25mm thick 24Kg/m³ density fibreglass insulation vapour barrier sealed as specified above.

Exposed cold air ducts in unconditioned spaces shall be insulated with 50 mm thick, 32 kg density, Fibreglass insulation vapour sealed as specified above with.

External and weather exposed insulated ducting shall be insulated as specified and then protected with a jacket of 20 kg roofing felt, all joints sealed with hot bitumen PBS PB4 or approved equal. The jacket shall be further mechanically secured to the duct with 6 mm wide soft aluminum bands, generally spaced at 450 mm. Indigenous coarse cloth, canvas roofing felt and asphalt impregnated kraft paper of approved quality are to be used.

Insulation shall be of manufacturers specified elsewhere in these documents. Insulating material shall be non combustible as defined in the NFPA standard 220.

1.1. Acoustic Insulation

Low velocity supply air ducts shall be provided with acoustic insulation for a distance of 15 linear feet from the fan discharge. Duct work sizes shown on the drawings are net clear sizes and wherever acoustic insulation is to be applied internally to the duct work, the Contractor shall suitably increase the duct sizes.

Acoustic insulation shall consist of semi-rigid bonded board of glass fibre, coated with black pigmented fire resistant coating on the side facing the air stream. The coating shall resist erosion up to 5000 Fpm. air velocities.

The insulation shall have a flame spread less than 25 per ASTM E 84-75. It shall have the following sound absorption characteristics per ASTM C 423-66.

	Octave Band Centre Frequency Hz.						
	125	250	500	1000	2000	4000	NRC
Thickness	Sound Absorption Coefficients						
1"	.13	.51	.46	.65	.74	.95	.60
2"	.25	.73	.94	1.03	1.02	1.09	.93

Application shall be per "Duct Liner Application Standard" published by the Sheet Metal and Air-conditioning Contractors National Association USA (SMACNA). All portions of duct designated to receive duct liner shall be completely covered with Duct Liner Boards. Transverse joints shall be neatly butted and there shall be no interruptions or gaps. Board shall be cut to assure tight overlapped corner joints. The coated surface shall face the air stream. The duct liner shall be adhered to the sheet metal duct with 100% coverage of adhesive. All exposed leading edges and transverse joints shall also be coated with adhesive. In addition, mechanical fasteners shall be used to secure the duct liner board.

Adhesive shall be specially formulated for this specific application and the Contractor shall ensure the prior approval of the adhesive by the Project Manager.

Fibreglass sound absorbing liner shall be of manufacturer's specified elsewhere in these documents.

The Bidder shall give complete technical details and manufacturer's technical bulletins for the acoustic insulation offered.

1.2. Pipe Insulation

All insulating materials required for piping shall be furnished and installed under this Contract. The execution of the work shall be by qualified insulation technicians, in strict accordance with the best practice of the trade and the intent of this specification.

(a) The schedule of pipe insulation is tabulated here-below:-

Service	Material	Thickness	Density
Chilled Water/ Hot Water (2" & smaller)	Fibre-glass (dual temp.)	1 inch.	64 Kg/m ³
Chilled Water/ Hot water (over 2")	Fibre-glass (dual temp.)	1-1/2 inch.	64 Kg/m ³
Steam and Condensate Return	Fibreglass (dual temp.)	2 inch.	80 Kg/m ³
Condensate Drain	Fibreglass (dual temp.)	1 inch.	64 Kg/m ³
Refrigerant Copper	Closed Cell Rubber Foam.	1 inch.	

(b) The insulating material thickness used for straight pipe, fittings and valves shall be insulated by applying mineral wool cement and finishing with cement. Over the cement a cover of 2.44 kg/m² canvas shall be applied with approved adhesive. This adhesive shall also be used (with colour tint, where so directed) to thoroughly saturate and coat the canvas.

(c) Insulation on chilled pipes shall be protected by saddles from hangers, guides and rollers. Hangers shall not pierce insulation. Where Fibreglass insulation is used on piping 50 mm and larger, a half section of Kaylo or cork pipe covering of equal thickness shall be used at metal shields.

(d) Piping which is exposed to weather, or called to be weather proof, shall be covered, in addition to insulation and finishes specified above, with 2.2 kg/m² roofing felt, lapped 75 mm on all joints, using adhesives specified above, and soft aluminum bands 300 mm apart and then clad with 0.5 mm galvanized metal sheet.

- (e) All vapour barriers shall be completely sealed against moisture penetration.

For chilled water piping, Fibreglass insulation shall have a factory applied Kraft reinforced foil vapour barrier and covering jacket. The jacket permeance shall not exceed 0.5 perm/cm. (ASTM E 96 Proc-A). Insulation and jacket shall have a flame spread of 25 or less per ASTM E 84-80. The thermal conductivity of insulation at a mean temp of 37.8° C shall not exceed 0.035 w/m-deg C.

Indigenous asphalt impregnated Kraft paper, canvas and roofing felt of approved quality are to be used. The tender shall confirm the type and thickness of insulation used and give details of vapour barrier, covering jacket, finishing and adhesive and supply manufacturer's technical bulletins.

1.3. Exposed Duct

Exposed duct insulated with 1" thick aluminium foil fibreglass insulation & 2" thick magnesia lagging covered with 18G ¾" mesh wire netting and an additional layer of ¾" magnesia lagging applied. The surfaces shall be finished with 26 gauge G.I sheet Jacketing.

C). AIR DEVICES

1. SCOPE

Supplying, fixing, furnishing, balancing and testing of Diffusers, Registers, Grilles & Louvers of different types and capacities as per drawings, specified herein and instructed by Consultant.

2. DESCRIPTION

- i). Diffuser, grilles and registers shall be factory fabricated constructed and shall distribute the quantity of the air specified, evenly over space intended without causing noticeable drafts over an air velocity of 50 F.P.M. in occupied zone or dead spots anywhere in the conditioned area. The contractor shall be responsible for correct diffusion, spread, drop, and throw. If according to the certified data of the manufacturer of the proposed units, the sizes indicated will not perform satisfactorily, the units shall be re-selected at no extra cost to perform quietly and effectively in accordance with the manufacturer's recommendations as approved by the consultant. A schedule of all air inlets and outlets indicating location, type specified air quantity, neck of face velocity, sound power level valves, pressure drop, throw and drop for registers, and maximum and minimum diffusion range shall be submitted for approval. The inlets and outlets shall be sound rated and certified in accordance with Equipment Test Standard 106 2R2 of Air Diffusion Council in sound power levels; decibels reference 10 – 12 watts, in octave bands 2 through 8. Diffusers and registers shall be provided with volume control and accessible operator. After the system is in operation, if excessive noise, draft, or dead spots, are noticeable in the conditioned spaces due to improper selection of type and size of diffuser or grille. The unit shall be changed to the proper size and type without additional cost.
- ii). Diffusers shall be furnished with anti smudge device, unless the diffusers unit minimizes calling smudging through design factors. Sponge rubber gasket shall be provided between ceiling and surface mounted diffuser or anti smudge ring. Duct plenum connecting the duct to diffuser shall be air tight and shall not be interfered with volume controller.
- iii). Grilles and registers shall be four-way directional- control type except that return and exhaust grilles may be fixed horizontal or vertical louver type. Each register shall be provided with removable key operated opposed-blade volume-control damper, Registers and Grilles shall be provided with sponge rubber gasket between flange and wall or cabinet, or ceiling. Four-way directional control shall be achieved by individual adjustment of horizontal and vertical vanes.
- iv). All diffusers, registers and grilles to be installed in fire rated walls or ceilings shall have one-hour rated fire dampers.
- v). All diffusers, registers and grilles shall handle the air quantities shown on the drawings at rated noise levels not to exceed the Noise Criteria Curve ratings shown below:

- a). Less than NC 30 for classroom, private offices, conference rooms, libraries, Residences, tape rooms and audio- visual rooms.
- b). Less than NC 40 for large offices, corridors, storage rooms, supply rooms, tea rooms and dining rooms.
- c). Less than 50 for shops, repair and maintenance areas, mechanical rooms and Generators room.
- vi). All diffusers shall be insulated directly to the supply air duct & shall be so installed that the collar shall be flush with ceiling. Gasket shall be used to prevent leakages.
- vii). Registers and Grilles on side wall shall be fixed on wooden frames provided with anti termite so lignum treatment.
- viii). Plenum for linear diffuser shall be fabricated for linear diffuser using 20 gauge G.I. sheet metal. Plenum shall be provided with hanging holes at every 1200 mm center, intake round spigots at 1200 mm center unless otherwise indicated on drawings, arrangements for fixing linear diffuser without visible screws & assuring leak proof fitting into the plenum.
- ix). The louver shall be provided with insert screen, so installed as to removable for cleaning & replacement.
- x). The blade & frame of exhaust & intake air louvers shall be of heavy gauge extended aluminum section provided with powder coating.

D). REFRIGERANT PIPING AND INSULATION

1. REFRIGERATION PIPING

Refrigerant piping shall be hard drain copper tubing with silver solder joints, type I, for low pressure and type K for high pressure side. Each circuit shall be complete with expansion valves, solenoid valves, necessary stop valves, filter driers, sight glasses and other specialties as per manufacturer's recommendation and as required for efficient operation and control of the air-conditioning system.

The piping shall be properly sized for the capacities and graded for proper refrigerant circulation and return of oil to the compressor for the lengths as indicated on the drawings.

The piping shall be adequately both horizontally and vertically with broad stop hangers over insulation at clamps/saddles/brackets so that the insulation is not pierced. The supports/hangers shall be spaced not over 5 ft. apart at fittings and specialties and not over 1 ft. from each change in direction. Pipe jointing and testing shall be carried out strictly as per manufacturer's recommendation prior to commissioning of the units.

2. REFRIGERATION PIPE INSULATION

Refrigerant pipe insulation shall be 1" thick Rubber foam insulation with reinforced aluminum foil vapor barrier. The insulation shall be fixed with 1" over lapped joints sealed with approved adhesive and covered 1-1/2" wide self-adhesive waterproofing tape of approved quality. The insulation shall be protected with 8 oz canvas jacketing.

E). DRAIN PIPING

1. CONDENSATE DRAIN PIPING AND INSULATION

Seal insulation joints with self adhesive Pvc tape. Piping with 3/6" thick rubber from insulation having Drain piping shall have an adequate water seal and horizontal and vertical support. Drain piping shall be installed with proper slope. Trap should be installed except split unit upto 3 TR capacity.

2. CONDENSATE DRAIN PIPING

- a). Install drain pipes as and where on drawing.

- b). Drain pipes shall be G.I. pipes (I.I.L.LIGHT GAUGE).
- c). Provide support at every 1 meter and at every change in direction.
- d). Drain pipe shall be installed with proper slope.
- e). Trap shall not be installed on small split unit's upto 2 TR capacity.
- f). Do not connect drain piping to drainage system Use indirect connection.
- g). Isolate drain pipe with closed cell foam insulation 3/8 inch thick and seal insulation joints with self adhesive PVC tape.

F). SOUND LINER

The low velocity supply air ducts shall, for a distance of at least 15 Ft. from the fan discharge and in return air plenum shall have duct liner 1" thick 1.5 LB. Cft. Density with a black felted face on the air side to resist air erosion. The liner shall be cemented on the ducting and further held in place mechanically. It shall have effective average noise reduction co-efficient not less than 0.8 and at 250 Cps. Below not less than 0.59.

The fiberglass sound absorbing liner shall be of Gustin Becon / Fiberglass Ltd. / Owens Corning / Johns-Manville / kimmco manufacture or equivalent.

The Bidder shall give complete technical details regarding the sound absorbing liner and arrangement offered by him.

G). VENTILATION AND EXHAUST AIR FANS

The Supplier shall furnish ventilation & exhaust fans of the type and capacity as specified and shown on the schedule. The Supplier shall be responsible for the proper selection of the fans so that the specified operating conditions are obtained. Motors shall be sized to provide the required BHP for meeting the specified conditions without overloading.

The fans shall be statically and dynamically balanced and tested in the factory. The fan-motor set shall be selected for quiet operation. The bearings may be sleeve, ball or roller type but must be silent running, heavy duty, self aligning type and to prevent leakage of oil or grease, preferably sealed and permanently lubricated otherwise, requiring only yearly lubrication with oil / grease cups provided in easily accessible positions. The fans shall be rated per ACMA standard 210 - 74 or ASHRAE standard 51-75 or equivalent.

The belt driven fans shall be provided with belt guard and variable pitch pulley to adjust fan speed +/- 10% of the design selected speed for the specified duty.

All fans shall have rubber-in-shear or spring type vibration isolators.

The axial fans shall have aerofoil impellers made of die cast aluminium alloy, driven by a squirrel cage induction motor and housed in hot-dip galvanized leakproof casing. The impeller shall be of adjustable pitch design. The fan shall preferably be direct coupled to electric motor, mounted inside the casing.

The propeller fan shall be direct driven by totally enclosed fan motors and shall be rigidly constructed and shall be free from objectionable noises and vibrations. Sealed, permanently lubricated ball or roller bearings shall be provided.

The fan should have fan inlet and outlets short flexible connections designed to prevent transmission of sound or vibration, but with minimum of air leakage.

The centrifugal fans shall be preferably of backward curved non-overloading type and have all welded heavy construction housing rigidly supported. Fans shall be driven through an adjustable speed V-belt drive. Fans shall be provided with outlet flanges. Motor and belt drive shall be provided with a belt guard, spring type vibration isolators for each fan for mounting. Sealed, permanently lubricated sleeve, roller or ball bearings shall be provided. The bearings shall be selected for 60,000 hours minimum life based on continuous operation at operating fan RPM. The fans to be suitable for 3 phase operation.

Roof exhaust fans shall be standard centrifugal roof exhausters. Fan wheels shall be of the backward inclined, centrifugal type, all welded construction. Fan motor drive and bearings shall

be mounted above the fan wheel in a compartment, isolating these components from the air handled by the fan. Fan shall have a weather roof hood hinged to the fan frame with stainless steel lock hasp, providing easy and ready access to the fan components.

ICT WORKS

METAL DETECTOR GATE

- Accurate Detection of magnetic, non-magnetic and mixed-alloy metal weapons
- Random alarm capability
- Fully digital design
- Standard Interfaces: RS-232, Infrared
- Protected against aging, weather and wear
- Very high detection speed
- Wide range of threat detection from guns to ½ cutter blade
- Proven reliability
- Ergonomic and robust design.

FIXED CAMERA

- Power: DC 12V
- S/N Ratio: $\geq 50\text{db}$
- Pixels: 1280(H) x 720(V)
- Lens: DC Iris
- Resolution: 1280x720 @ 25/30fps
- Protocol: TCP/IP, DHCP, HTTP, UDP etc
- Video Compression: H.264
- Temperature: $-10^{\circ}\text{C} \sim 55^{\circ}\text{C}$
- Weatherproof: IP66.

HYDRAULIC ROAD BLOCKER

- Power: 220V
- Provides protection against unwanted entry or exit
- It can be operated manually in case of power failure
- Durable electro-hydraulic driven mechanism
- Sufficient space for system maintenance
- It can bear up to 100 Ton vehicle weight easily when allowed to pass
- Blocking width up to 8, 10 & 12 feet upon requirement.

UVI SYSTEM

- Weatherproof: IP65
- Power: 220VAC
- Capable of capturing vehicle number plate
- Weather Sand, Dust and Grit Resistant
- Capable of capturing driver image
- Lowest cost and highest flexibility.

BOOM BARRIER

- Power: 220 V \pm 10% AC
- Temperature: -40 °C - +75 °C
- Rated Power: 120 W
- Motor: AC
- Working Cycle: 50%
- Opening Time: 1s, 3s, 6s.

MINI DOME CAMERA

- Compression: H.264/ MPEG/ MJPEG
- Power: 12 VDC
- Weatherproof: IP66
- Resolution: 1280x960
- Protocols: TCP/IP, UDP, RTP, RTSP, RTCP, HTTP, DNS, DDNS, DHCP, FTP, NTP, SMTP, UPNP and other supported protocols.
- Temperature: -10°C ~ 60°C.

X-RAY BAGGAGE

- Power: 220V AC
- Noise: < 55 dB
- Temperature: 0°C - 45° C
- Conveyor Speed: up to 0.22 m/s
- Conveyor Max Load: up to 50 kg
- Resolution: 1280 x 1024
- Duty Cycle: Rated for 100% Duty Cycle
- Alarms by sounds and light when conform to condition.

TYRE KILLER

- Short Operating time of the spikes
- Low maintenance
- Installation in all climatic zones possible
- Tri-protect corrosion Protection.

PLUMBING WORKS

SYSTEM DESCRIPTION

Standards mentioned or referred to on the drawings and this Specification shall be the prevailing Standard Code of Practice in Pakistan.

In these Specifications or other documents, foreign standards as listed below are to be used as comparable standards for convenience:

- i. British Standards Institute
- ii. British Standard Codes Of Practice
- iii. Pakistan Standards Institute
- iv. American Society for Mechanical Engineers (ASME)
- v. American Society for Testing Materials (ASTM)
- vi. Underwriter's Laboratories, Inc.(UL).
- vii. American Society of Plumbing Engineers
- viii. The Institute of Plumbing, UK
- ix. Chartered Institution of Building Services Engineers
- x. National Fire Protection Authority

1.1 Testing Institutes / Laboratories

Contractor must use institutes/laboratories for testing of materials as approved by the Consultant/ Engineer.

1.2 Scope of the Contract

The work included in the Contract comprise the furnishing and installing of all materials and equipment necessary to form the complete construction of the works shown on the Contract drawings and/or described in the Specification.

The construction materials, equipment, finishes, fixtures etc. shall be the same of closely similar to those shown on the Contract drawings and/or described in this Specification.

All works shall be constructed in accordance with the Specification and with the Contract drawings and approved shop drawings.

The Contractor shall be responsible that all materials and items, mentioned and/or described in this Specification and Additional Technical Requirements (ATR) if any and/or shown on the drawings and/or deemed necessary for the proper and workmanlike execution of this project will be supplied, processed, fixed, finished and tested by him unless specifically stated otherwise in the Contract documents.

The Owner reserves the right to engage other specialist Contractors on this project and/or to procure any additional materials required for this project directly from suppliers.

1.3 Site Visit

The Contractor will be deemed to have visited the site and acquainted himself with the nature of the ground, means of access, existing structures, space available for storage of materials and erection of sheds etc. It will further be presumed that the Contractor has obtained all relevant information regarding availability of water, electric power and materials required for the Works. No claim resulting from lack of knowledge or failure comply with this clause will be entertained.

1.4 Plant, Etc.

The Contractor shall provide everything necessary for proper and efficient execution of the Works in orderly sequence including all requisite tools, tackle, plant, scaffolding, hoists, machinery, labour, haulage, materials and storage sheds, etc. required by the Contractor and clearing away all items at completion or as they become superfluous and making good all or any damage caused. All plant and especially the scaffolding material shall be of good quality, well maintained and without defects. Bamboo scaffolding shall not be used unless with the express approval of the Consultant/Engineer and only for very limited heights.

1.5 Sheds, Offices, Etc.

The Contractor shall provide and erect all temporary workshops and sheds that may be necessary for the storage and protection of materials and also suitable furnished offices for his Works Staff.

The Contractor shall further provide and erect all necessary proper sanitary and other accommodation for the use of the workers engaged on the site and keep in clean condition and clear away when no longer required. This requirement will be strictly enforced by the Architect/Engineer so as to prevent use of other places for sanitary purposes by the workers.

Before any temporary structures can be erected, the Contractor shall obtain the express approval of the Owner concerning location and the appearance of such temporary structures. The Contractor shall provide the above temporary buildings with required electrical installation, water supply and sewage system and shall connect same with appropriate service mains. The cost for water, electricity and for public communication services for all temporary sheds, offices etc. shall be borne by the Contractor.

The Contractor shall take down all sheds, etc. on completion or when instructed to remove from the site and make good all disturbed work.

1.6 Temporary Power

The Contractor under this Contract appointed by the Employer shall at his expense obtain connection and shall provide temporary power and/or artificial lighting required for the execution of the Works and for temporary provision and offices.

The temporary site distribution system for electrical power shall be made available by the Contractor to other contractors engaged on this project, but the cost of actual power consumption will be reimbursed by such other contractors to the Contractor of this Contract.

1.7 Protection of Adjacent Structures

During the entire period of the execution of Works on the project site under this Contract, the Contractor shall be fully responsible for any damages to structures, services, roads, fences, long, drains, etc. that are located on or at the border of adjacent plots and any such damages resulting from the Contractor's operation shall be made good by the Contractor at his own expense and to the complete satisfaction of the Consultant/Engineer.

1.8 Welfare and Safety

The Contractor shall allow for providing and maintaining welfare facilities and suitable adequate safety measures for the protection of workers and visitors to the Works; such facilities and safety measures shall be to the satisfaction of the Consultant/Engineer and shall be also in accordance with any statutory requirements in force at the time.

1.9 First Aid

The Contractor shall provide on the project site an adequate and easily accessible First Aid Outfit or such outfits as may be required in any Government Ordinances, Factories, Acts, etc., subsequently published and amended from time to time. In addition at least one person, who will be permanently on the site, shall have practical knowledge of basic first aid principles and shall be instructed in their use, and the person(s) so designated shall be made known to all employees by the posting of his or their name(s) and designation in a prominent position in the site area.

1.10 Programmed of Works and Method of Construction

For a proper scheduling of the times and activities required for execution of this project, the Contractor shall submit a construction-programme within 7 days after the signing of the Contract, stating:

- (i) Proposed dates for starting and completing construction of various parts of the Works.
- (ii) Proposed dates for procuring materials, plant and equipment.
- (iii) Proposed hours of site work for Contractor's personnel.

- (iv) Proposed dates for shipment and arrival on the site of principal construction material.

This programme shall be in such form, and by using such method of planning, that delays and the effects of delays can be discovered at any early stage and that steps can be taken to prevent or correct such delays.

1.11 Work Diary

The Contractor shall keep a diary on the site in which shall be recorded the following essential information. The diary shall consist of a standard form to the approval of the Engineer.

- a) Workers on site, of the Contractor and his sub-Contractors.
- b) Materials on site, materials supplied and materials used or installed under this Contract.
- c) Equipment on site.
- d) Progress of the works of the Contractor and his sub-Contractors.
- e) Delays in planned progress of the works of the Contractor and his sub-contractors.
- f) Engineer's instruction and variation of orders received.
- g) Drawings and revision of drawings received.
- h) Special occurrences, accidents, etc.

A copy of the diary in the form of Daily Report approved by the Architect/Engineer shall be submitted daily to the Architect/Engineer for his perusal.

The original diary shall become the property of the Owner.

1.12 Samples

Samples required by the Engineer are to be provided without delay at the Contractor's expense and shall, if required, be in accordance with the relevant standard method of sampling. The samples will be taken in such a way and such a method that they can be considered to be representative of the full quantity of materials or work from which they are taken. The samples, when approved, will be kept by the Consultant/Engineer, who will reject materials or workmanship not corresponding in quality and character with the approved samples.

Suitable, labeled boxes or containers for the storage of samples shall be provided by the Contractor at his own expense.

1.13 Inspection and Tests

Materials shall, unless otherwise directed by the Consultant/Engineer, be tested before leaving the manufacturer's premises and the Contractor shall obtain and supply to the Engineer's representative for his approval certificates from the manufacturer, showing that the materials have been tested according to the relevant specification or standard. The certification from the manufacturers in no way absolves the Contractor from his responsibility of retesting the materials from approved laboratories/agencies.

The Contractor shall provide labour, where required, for tests carried out in accordance with the Contract.

The cost of all tests shall be at the expense of the Contractor.

1.14 Proprietary Materials and Articles

Where in this Specification mentioned makes or named products of individual manufacturers this is only an indication of the quality and type of goods which are satisfactory to the Consultant/Engineer. The Contractor may substitute similar products of at least equal quality and suitability, subject to the Contractor proving the quality and suitability and to the approval of the Consultant/Engineer.

1.15 Working Drawings on Site

Working drawings for all works are to be kept on site at all times. The drawings shall be in a good readable condition and of the latest issued revision. The term "working drawings" means either the contract drawings, later issued execution drawings or shop drawings made by the Contractor.

1.16 Shop Drawings and As-Built Drawings

Where required in this Specification and where considered necessary for proper execution of the Works, the Contractor shall prepare the detailed and shop drawings shall be issued to the Consultant/Engineer in duplicate for checking and approval. The Contractor shall supply to the Engineer and to other contractors concerned (5) prints of the final approved drawings.

The Contractor shall prepare as-built drawings for all executed works. The Contractor shall submit to the Owner the originals (reproducible) of his shop drawings and of the as-built drawings five copies on printing paper. The drawings shall be submitted to the Consultant/Engineer for approval prior to the issue of the Certificate of Completion.

1.17 Contractor's Staff

The Contractor shall make available for this project all staff members that will be required for the proper and smooth running of the project and to ensure timely completion. Such staff shall have proper qualifications and experience for the disciplines that they will be engaged on.

The Contractor shall propose, for the approval by the Consultant/Engineer, his senior staff members for the following disciplines:

- (a) Programming and Scheduling of the Works, liaison with other contractors.
- (b) Selection and Ordering of plumbing materials.
- (c) Organization of the works and quality control.
- (d) Surveying.
- (e) Preparation of shop drawings and as-built drawing.

The Contractor shall also submit at the same time, for the approval by the Consultant/Engineer, the names and qualifications of other staff that will be employed on this project, including but not limited to the name of the Superintendent of works as mentioned in the Conditions of Contract.

GENERAL REQUIREMENTS OF PLUMBING AND SANITARY SERVICES

1. GENERAL

All fixtures shall be free from imperfections, true as to line, angles, curves and colours, smooth, water tight and complete in every respect.

All fixtures specified to be of vitreous ware, shall be fired vitreous China ware of the best quality, non-absorbent and burned so that the whole mass is thoroughly fused and vitrified producing a material white or coloured, which when manufactured will show a homogeneous mass, close drained and free from pores. The glazing and vitreous china fixtures shall be of colour approved by the Consultant / Engineer, thoroughly fused, and united to the body, without discoloration, chips, or flaws and shall be free from craze. Cracked or other imperfect fixtures will not be accepted.

All plumbing fixtures proposed to be supplied shall be indicated at the time of tendering, and all fixtures should be approved by the Consultant / Engineer, prior to installation.

All fixtures shall be furnished by one manufacturer unless otherwise specified.

All fittings, cast brass set screws, escutcheons faucets, traps, exposed piping etc. shall be of brass, chrome plated over nickel plate with polished finished. All supports nut, etc. visible shall likewise to chrome plate over nickel plate.

After insulation of plumbing accessories, the Contractor shall ensure their protection against damage, misuse and general deterioration. Fixture outlets shall be plugged with suitable material to prevent entry of external debris. All chrome plated and other metallic fittings shall be provided with a coat of grease to prevent their deterioration. All items prior to handing over must be in perfect condition in the visual and operational sense.

All CP. fittings and accessories shall be first quality, locally manufactured, unless otherwise indicated.

EXTERNAL / INTERNA WATER SUPPLY SERVICES

1. SCOPE OF WORK

The work shall supply installation, testing, commissioning, adjustment and setting to work of the Plumbing and Water services installation.

The contractor is to assume full responsibility for the correct functioning of the system and to carry any liability or guarantee as may be necessary to protect all parties in this regard.

The plumbing services contractor shall be responsible for coordination with other trades and services and shall provide all materials, labour and supervision, equipment, tools, appliance, services, etc. for carrying out the following items of works:

- Domestic hot/hot water return and cold water installations.
- Thermal and protective insulation of pipe work, plant and equipment installed within the plumbing and drainage contract.
- Protective painting of all materials installed within this section of the contract.
- Identification of all services.
- All builder's work including breaking and making good of walls, floors, etc., equipment foundation pads, sleeves, etc.
- Hoisting of heavy equipment.

2. WATER SUPPLY SERVICE

2.1 General

Supply, fixing, testing and commissioning of water supply system, including pipes, accessories, valves, etc., as specified in other sections and herein: as shown on drawings and instruction of Architect / Engineer.

2.2 Water Supply System Description

- i. Water supply should be in accordance with the bye-laws and regulations of the water supply authorities and executed to their specifications.
- ii. Water shall be pumped from underground tank to the overhead tank through pump WP-01 (1No. working 1No. standby) & WP-02 (1No. working & 1No. standby) installed at the pump room. The pump WP-01 & WP-02 shall be started automatically on fall of water level in the overhead tank. The pump shall be stopped when the overhead tank has filled. Safety to avoid the dry run of the pump shall be incorporated in the control panel by providing flow switch and timer. From overhead tank water shall be supplied to toilets Kitchen through gravity System.

3. MATERIAL AND INSTALLATION

3.1 Pipe work & Fitting

uPVC schedule 40 pipes fittings with solvent joint will be used for cold water pipes sizes dia 3" and above

Polypropylene Random (PP-R) pipes a fittings confirming to Din 8077 with fusion jointing will be used for cold /hot & hot water return pipe size to (dia 20 mm to dia 90 mm).

Polypropylene (PE-80) sdr-17.6 pipes a fittings confirming to BS 6572:1985 with fusion but welding jointing will be provided for cold water pipes underground outside the building

The galvanized pipes shall conform to British Standard 1387 Specifications for "Steel Tubes and Tubular suitable for screwing to B.S. 21 pipe threads". Pipe of 1/2" to 2-1/2" diameter may be of medium or heavy quality as per (BOQ) item.

3.2 G. I. PIPE

All screwed pipes and sockets shall have B.S. pipe thread in accordance with BS. 21. In order to prevent damage to the leading thread, the ends of the sockets shall be chamfered internally. A complete and uniform adherent coating of zinc will be provided for galvanized pipes. Every pipe length shall be tested at the manufacturer's place to a hydraulic test pressure of 483 N/cm square (700 lb./sq.in) and shall be maintained at the test pressure sufficiently long for proof and inspection. Pipes which are bundled shall be secured together by rope or soft iron or other suitable material. The threads of all pipes shall be effectively covered with a good quality grease or other suitable compound, and each pipe above 40 mm (approx.: 1-1/2") nominal bore shall have a protecting ring affixed to the un-socketed screwed end. All pipe fittings up to 3" dia. shall conform to B.S. 21 and shall be of malleable cast iron. Underground GI pipe work shall be painted with two coats of black asphalt paint or two coats of bitumen wrapped with Hessian cloth or shall be applied one layer of PVC wrapping tape with 20% overlap. Screwed joints in G.I. pipes shall be made perfectly tight, without the use of any filler except approved jointing compound or tape wherever required to make flanged joints, they shall conform to BS 10 Table D.

3.3 Installation work

Unions and flanges should be furnished and installed at each threaded or flanged connection to all equipment or valves. The faces of flanges being connected should be alike in all cases. Unions and flanges should be located so that pipe can be easily disconnected for removal of equipment, valve or tank. The run and arrangement of all pipes shall be as shown on the drawings and as directed during installation. All vertical pipes shall be erected plumb and shall be parallel to wall and other pipes. All horizontal runs of piping shall be kept close to walls. If required to change the location etc. during the currency of the work, the Contractor will do so at no additional cost. Embedded pipes shall run in chases before the plaster work is finished and chases closed properly with cement mortar (1:4) after an approved pressure testing of pipe work by suitable and substantial number of hangers supports and clamps of approved type and make shall be provided for all horizontal and vertical piping. Horizontal piping shall be supported as per schedule given in drawings:

Hangers shall be supported from approved concrete inserts in concrete slab. No piping shall be hung from the piping of other systems. Long radius bends shall be used wherever possible.

Furnish and install all pipe passing through walls with sleeves of G.I. sheet 18 gauge, the inside dia, of which shall be at least 1/2" greater than the outside of the pipe passing through it. Sleeves in exterior walls and pits shall have anchor flanges and space between pipe and sleeve shall be caulked water-tight. All pipes passing through floors shall be provided with 18 gauge G.I. sheet sleeves properly anchored to the floor. At water proof locations, and approved waterproof type pipe sleeve shall be provided.

All M.S. hangers, brackets, etc., shall be given one coat of red oxide primer and two coats of synthetic enamel paint. All exposed G.I. piping shall be given two coats of synthetic enamel paint. Materials for painting shall be high quality products of a well known manufacturer and shall be approved by the Engineer before using. The piping shall be painted according to a color code approved by the Engineer.

All water distribution system shall be tested whole or in part to 1-1/2 times the working pressure but not less than 10 psi. The Contractor shall pay for all devices, materials, supplies, labor and power required for the test. The test will be run for two hours at revealed by the test shall be repaired and the whole test return until the system proves to be satisfactory.

4. CENTRIFUGAL WATER SUPPLY PUMPS

- i. The centrifugal water pump shall be complete with pump, frame, CC foundation, starters suitable specify electric motor, discharged and suction connection with valves and accessories as per typical connections of pump shown on the drawings.
- ii. The pump shall be suitable for quite and continuous operation at actual head and discharge, the pump shall be closed coupled type, single stage, cast iron body and impeller.

- iii. The casing and bearing housing shall be of cast iron, highest point in the casing should be provided with air vent and lowest point should be provided with drain plug.
- iv. The shaft seals shall be mechanical seal type.
- v. The impeller, impeller guide, glands, stuffing box ring, and shaft sleeve shall be of cast iron.
- vi. The shaft shall be of steel, turned and ground.
- vii. The bearing frame assembly of the pump should be fitted with non-graspable ball bearing equivalent to electric motor's bearing standard.
- viii. The pump and motor shall be mounted on a common base plate of heavy structural steel.
- ix. The pump casing shall be designed to withstand a discharge head specified plus the static head on system plus 50% of total head, but not less 10 Bars.
- x. The electric motors shall be drip proof type provided with suitable starters and totally enclosed. Fan cooled type, with overload protection.
- xi. The pumps shall be non-overloading at any point on the characteristic curve.
- xii. The flexible connection shall be provided on discharge of the pump.
- xiii. Electric motor shall have Class "F" insulation for high ambient temperature.

5. VALVES

Unless otherwise specified, valves should be of the same nominal size as the size of the pipe line to which they are connected. All valves that incorporated packed glands should be capable of having glands packed when connected in line and subject to the working line pressure.

All isolating valves shall provide tight shutoff in the closed position.

All hand wheel valves shall rotate clockwise to close the valve. Check valve should be installing in a plane only which is recommended by the manufacturer and approved by the Consultant/ Engineer.

Valve bonnets and covers should be easily removable and the gasket and glands should be readily renewable.

All gate and sluice valves shall incorporate guides in the body to ensure the correct position of valve discs at all times. The working parts of valves and cock should be bronze and the body casting should be bronze for valves and cocks up to 2" connection and cast iron for valves and cock of 2-1/2" diameter connection and above.

Gland rings and spindles should be of a good running fit and stuffing boxes should be fitted with neoprene 'O' ring seals. The exterior finish of all bronze valves bodies should be polished except otherwise specified.

Check valves up to and including 2-1/2" diameter should be of 'Y' pattern swing type having regrindable bronze discs with the disc seat integral with the valve body. The disc and seat should be accessible via a screwed cap for regrinding without removal of the disc.

Isolating valves for all water piping should be full way type gate valves unless otherwise indicated and should be fitted in the following positions, whether shown on drawings or not:

- Inlet and outlet connections to pumps.
- Inlet and outlet connections to water strainers and filters
- Inlet and outlet connections to tanks.
- Inlet and outlet connections to three Port Valves.
- By pass connection around valves and equipment.
- Branch connection from service mains.
- At top or base of the riser served from below or above.

Ball float valve should be the internally hydraulically balanced double seated pattern. The operating mechanism should be properly fixed to an arm of brass which in turn shall be fixed to tinned copper float. The valve shall be of bronze body. The valve faces shall be synthetic rubber. The hinge pin and bushes shall be copper alloy.

Regulating valves for all water services for size 2" and smaller should be lock shield pattern disc type with parabolic shaped slotted disc and shall regulate the flow in proportion to the lift of disc.

Regulating valves larger than 2" size shall be globe pattern valves.

Bib cock shall be male inlet, face of wall type and chromium plated. Pressure relief valves shall be spring loaded angle type, water pressure relief valve located in water line and constructed with semi-steel body, bronze trim.

6. STRAINERS

Strainer should be 'Y' pattern and cast iron body, working pressure should be equal to or greater than the maximum water pressure. The drain cock should be provided for cleaning purpose.

7. END CAPS

Should be machined, gasketed and with straight threads or bolted type.

8. UNIONS & FLANGES

Unions and Flanges should be furnished and installed at each threaded or flanged connection to all equipment or valves. The faces of flanges being connected should be alike in all cases. Unions and flanges should be located so that pipe can be easily disconnected for removal of equipment, valve or tank.

9. PUDDLE FLANGES

Pumps section and supply pipe connection work passes through the external walls of the buildings, underground tank & over head tank wall required level, the Contractor shall supply and cast or build puddle flanges into the structure. Show on the detail drawing.

10. PIPE INSULATION

All hot water supply pipe work shall be insulated with canvas cloth 8oz closed cell electrometric rubber foam with density off $55 \div 70 \text{ kg / m}^3$ with thickness of 19mm.

11. PRESSURE REDUCING VALVE

11.1 Pressure reducing valves shall be pilot controlled, hydraulically operated, diaphragm type with low bypass capability. The low flow bypass capability shall be achieved by using a balanced direct acting PRV as an integral part of the main valve. At very low flows when the main valve is almost completely closed, to prevent the possibility of cavitations the direct acting valve shall bypass the main valve and maintain flow threaded PEX or Cpv's quick-connect end connection with threaded union.

11.2 PRVs shall be bronze construction including the trim. The pressure reducing valves shall be suitable for maximum working pressure that exist within the system and downstream pressure should be site adjustable between 2 and 5 bar. Water supply drawings for the minimum locations at which PRVs shall be required.

11.3 Valves shall always be installed in accessible locations to permit easy operation and maintenance.

12. AUTOMATIC AIR VENT VALVE

12.1 Automatic air vent (eliminators) shall be provided at all high points in water pipe work system and as shown on drawings. They shall be installed at the highest points of the sections they are intended to vent.

- 12.2 Air vents on water systems shall be of float type, air eliminator of approved manufacture, having bottom inlet and top outlet with screwed connections. They shall have a stainless steel float valve and valve seat, incorporate a stainless steel check valve and shall be so designed as to allow the internal parts to be removed for maintenance or inspection without disturbing pipe work. Air vents shall be suitable for the system pressures and temperatures. An air release pipe shall be connected to the air outlet and taken to the nearest suitable discharge point. Insect screen shall be provided on all open vents and overflows.

13. HYDROSTATIC TESTING OF WATER PIPING SYSTEMS

- 13.1 All water piping systems shall be hydrostatically tested for at least 1.5 the working pressure for ensuring complete tightness under the test pressure and for the duration of time as specified under the respective system concerned.
- 13.2 Systems may be tested as a whole or in sections to facilitate the progress of the work.
- 13.3 No part of any piping system shall be tested to pressure less than 150psi specified test pressure measured at the highest point of the system.

14. STERILIZATION / CHLORINATION

After installation and testing complete domestic water system, reservoirs, storage tanks, mains, hot or cold water piping etc. have been installed and tested shall be sterilized by the following method.

A solution of chlorine gas and water containing not less than 50 ppm of free chlorine shall be injected into the system, in such a manner as to ensure that the entire system is completely filled with the solution. During this procedure all valves shall be operated and outlets shall be tested for residual chlorine, injection shall continue until all outlets indicate at least 50 ppm of free chlorine.

After injection, the system shall be isolated and the solution be held in retention, for a period of not less than 24 hours. Tests shall be made for residual chlorine after retention. If such tests indicate less than 50 ppm of residual chlorine, the entire procedure shall be repeated. After satisfactory sterilization has been effected, the system shall be flushed from any approved source, until all traces of chlorine content is no greater than that in the existing supply.

Until sterilization of the water system has been made, the contractor shall have signs posted at proper locations stating that the water system has not been sterilized and shall not be used for human consumption.

A certificate of sterilization/chlorination, together with bacteriological reports shall be prepared and submitted to the Engineer Incharge stating the work has been done in accordance with the specifications set for the above and prior to final acceptance of the installation.

15. CORRECTION AFTER COMPLETION

- 15.1 Remedy all work in accordance with the General Conditions of Contract during the Maintenance period.
- 15.2 Attend immediately to any and all the defects occurring during the period defined above and repair in a manner to prevent recurrence. This contractor is responsible for all work required by other trades necessary to repair the works of this section, or necessary to repair damage caused by the failure of any part of this section.

16. GUARANTEES

- 16.1 The Contractor will guarantee all material and workmanship for at least 12 months after preliminary take over by the Owner.
- 16.2 All guarantees from equipment suppliers will be vested in the Owner, regardless of whether the Contractor who supplied the equipment is still associated with the project or not.

- 16.3 Guarantees will be full guarantees and will include all overhead, profit, incidental charges and sundries.
- 16.4 Where damage is caused to any other item by any failure of the item guaranteed, then the guarantee shall also include the costs incurred in rectifying that damage.

17. MAINTENANCE

- 17.1 Maintenance is defined as the Contractual Liability to maintain the equipment in working condition, PLUS the regular checks and servicing of equipment during the maintenance period, including all the consumables and spare parts to keep the equipment in best working order.
- 17.2 Regular maintenance shall be as necessary, but in any event not less frequently than monthly. Breakdown calls shall be attended immediately.
- 17.3 Maintenance period shall be 1 year from the date of handing over for all fire fighting works.

SOIL, WASTE / VENT / RAIN / DRAINAGE & SEWERAG SYSTEMS **INTERNAL EXTERNAL PLUMBING SERVICES**

1. SCOPE OF WORK

- a) The work shall include supply, installation, testing, commissioning, adjustment and setting to work of the drainage installation.
- b) The contractor is to assume full responsibility for the correct functioning of the system and to carry any liability or guarantee as may be necessary to protect all parties in this regard.
- c) The drainage services subcontractor shall be responsible for coordination with other trades and services and shall provide all materials, labour and supervision, equipment, tools, appliance, services, etc. for carrying out the following items of works:
 - Drainage connections of plumbing fixtures, floor gully and drain.
 - Soil and waste drainage system
 - Storm water drainage systems
 - Sewerage system
 - Protective painting of all materials installed within this section of the contract.
 - Identification of all services.
 - All builder's work including breaking and making good of walls, floors, etc., equipment foundation pads, sleeves, etc.
 - Hoisting of heavy equipment.

2. EXTERNAL SOIL / WASTE & RAIN WATER NETWORK

- i) The soil / waste system shall be double stack together with vent installation. All work shall be installed and tested in accordance with BS 5572 code of practice for sanitary works.
- ii) Surface water drainage network
- iii) Rain water from the roof shall be piped down via separate pipe work to connect as shown on drawing.
- iv) Rain water shall be free discharge at ground floor as per detail drawing.

2.1 Installation

- a) uPVC Vent pipes shall extend through roof and terminate 600mm above it with vent cowl. Vent pipes passage through the roof shall be made watertight by proper flashing.
- b) All changes of direction shall be gradual and not abrupt, 45 degree fittings shall be used wherever possible, and 90 degree fittings shall be of the long sweep type. All unnecessary turns and off sets shall be carefully avoided, and run as directly as possible from the sanitary fixtures to the vertical stacks.
- c) Concealed pipes shall be installed in such a manner as to permit easy accessibility for maintenance this applies particularly to valve locations.
- d) All pipes shall be fixed in neatly arranged lines, and adequately pitched horizontal lines to allow the system to be properly vented and drained. Air pockets, traps and sags shall be carefully avoided.
- e) Supports, clamps and hangers shall be made of galvanized steel with rubber internal rubber seal, fixed with drilled plugs. Cutting and pinning of fixings will not be permitted.
- f) Run building drains at a minimum grade of 1% (1:100) pitch unless otherwise noted, downward in the direction of flow. Pitch branch connections to stacks from fixtures at 2% (1:50) where possible.

- g) Provide all the required appurtenances to make the drainage system complete in compliance with code requirements including traps, pipe fittings, hangers, and the like.
- h) Wherever possible, vent stack offsets shall be made with 45 degree fittings.
- i) Take special care in setting roof drains to ensure that they are set at an elevation which will preclude formation of puddles.
- j) Install connections to roof drains in conjunction with the roofing specified under civil works, so that the building is adequately protected during construction from damage by storm water.
- k) No short radius bends to be used. Use short "Tee-Wye" fittings in vertical piping only.
- l) Any piping passing through roofs shall be so arranged to be a minimum of 300mm from walls or other obstructions so as to permit proper flashings which are provided by another trade.
- m) Where drainage pipe work crosses fire rated partitions, walls and floors, provide proprietary fire rated in tumescent sleeves with a fire rating equal to or greater than the fire rating of the respective wall or floor.

2.2 Material

- a) Unless otherwise indicated drainage, vent and rain water pipes and fittings inside the building (except Toilet / Kitchen / Retail areas) shall be of uPVC to BS 4514 for pipe sizes up to 80mm dia and MuPVC / ABS to BS 5255 for pipe sizes 50mm dia and smaller. Fittings shall be push fit type.
- b) All pipes under building and those subject to traffic especially under roads shall be protected with reinforced concrete.

2.3 Cleanouts

- a) Cleanouts shall be installed at each change of direction of drainage pipes, greater than 45 degrees, inside the building, and where indicated on the drawings. Cleanouts shall be not more than 10m apart in horizontal lines. A cleanout shall be provided at or near the foot of each vertical waste or soil stack.
- b) Cleanouts on concealed piping shall be extended through and terminate flush with finished wall or floor. Pits or chases may be left in the wall or floor, provided they are of sufficient size to permit removal of the cleanout plug and proper cleaning of the system.
- c) Where it is necessary to conceal a cleanout plug, a heavy duty covering plate shall be provided, which will permit ready access to the plug.
- d) Cleanout plugs shall be of heavy duty stainless steel (304) polish finish wall thickness min. 2mm with seal and lock. Final finish shall be to the approval of the Consultant/Engineer.
- e) Cleanouts shall be of the same nominal size as the pipes up to 100mm pipe diameter and not less than 100mm for larger piping.
- f) Cleanouts shall be so installed that there is a clearance of not less than 45cm for the purpose of rodding and cleaning.
- g) Provide cleanouts at foot of all stacks, changes of directions, at the ends of branch runs, in straight runs as required and where indicated. Terminate as specified under "Cleanouts".

2.4 Floor & Roof / Drains

- a) Floor drains unless otherwise indicated shall have uPVC traps of minimum water seal of 70 mm, and shall be provided with adjustable and removable strainers. The open area of strainer shall be at least two thirds of the cross-sectional area of the drain line to which it connects. Floor drains shall have heavy duty stainless steel (304) polish finish cover wall thickness 2.0mm with a removable strainer and cover plate. Floor drain shall have built in rodding eye.

- b) All floor drains / cleanouts must be coordinated with floor tiling layout.
- c) Dish washer drains, in kitchen areas, shall include a nickel bronze funnel secured to the grating.
- d) Roof Rainwater outlet shall be Promenade roof drain outlets, as per detail drawing & as by Wade, or approved equal.

3. HUB-LESS CAST IRON DRAINAGE NETWORK

- a) The piping system shall be of hub-less cast iron ASMT pipe and fittings with stainless steel clamp (316) joints with applicable pressure rating and installation shall be carried as per. Shall be installed show on detail drawing.
- b) Building Upvc soil / waste & rain water pipes connected to cast iron drainage network shown on the basement drawing & detail drawing.

3.1 Installation

- a) Hub-less cast iron pipes shall extend through below floor slab and under the slab including fittings. Vent pipes passage through the roof shall be made watertight by proper flashing.
- b) All changes of direction shall be gradual and not abrupt, 45 degree fittings shall be used wherever possible, and 90 degree fittings shall be of the long sweep type. All unnecessary turns and off sets shall be carefully avoided, and run as directly as possible from the sanitary fixtures to the vertical stacks.
- c) Concealed pipes shall be installed in such a manner as to permit easy accessibility for maintenance this applies particularly to valve locations.
- d) All pipes shall be fixed in neatly arranged lines, and adequately pitched horizontal lines to allow the system to be properly vented and drained. Air pockets, traps and sags shall be carefully avoided.
- e) Supports, clamps and hangers shall be made of galvanized steel with rubber internal rubber seal, fixed with drilled plugs. Cutting and pinning of fixings will not be permitted.
- f) Run building drains at a minimum grade of 1% (1:100) pitch unless otherwise noted, downward in the direction of flow. Pitch branch connections to stacks from fixtures at 2% (1:50) where possible.
- g) Provide all the required appurtenances to make the drainage system complete in compliance with code requirements including traps, pipe fittings, hangers, and the like.

4. PIPE SUPPORT

Spacing for supports

(32 mm)	-	(1.2 m)	(1-1/4")	-	(3'.6")
(40 mm)	-	(1.2 m)	(1-1/2")	-	(3'.6")
(50 mm)	-	(1.2 m)	(2")	-	(3'.6")
(80 mm)	-	(1.0 m)	(3")	-	(3'.0")
(110 mm)	-	(1.0 m)	(4")	-	(3'.0")
(150 mm)	-	(1.0 m)	(6")	-	(3'.0")
(200 mm)	-	(1.0 m)	(8")	-	(3'.0")

- a) All pipe supports shall be manufactured in accordance with BS. 3974 Part 1: 1974. All steel work used for the fabrication of hangers, pipe supports brackets and anchors, should be hot dip galvanized after fabrication. All fixing hardware shall be either of galvanized iron. Complete pipe work shall be supports with properly made hangers and supports as per manufacturer's recommendations. Anchors will be where as required.
- b) All exposed to weather hangers and supports will be further protected by applying zinc primer before fixing and then two coats of enamel paint of approved make & colour.

5. PIPE EXPANSION

- a) Pipe work shall be supported in such a manner as to permit free movement due to expansion and contraction. Pipe work supports shall be arranged as near as possible to joints and changes in direction and each support shall take its share of the load. The spacing of the supports shall not exceed the intervals given elsewhere herein. Where there are two or more pipes the support spacing may be based on the centers required by the smallest bore pipe work.
- b) Vertical rising pipe work shall be supported at the base or as indicated to carry the total weight of the riser. Branches from risers shall not be used as a means of support for the riser.
- c) Provision for movement due to expansion and contraction shall be made either by loops, special expansion joints or by changes in direction of the pipe work. Supports at such points shall be arranged to ensure that all movement is taken up by the loop, joint or change in direction of the pipe work.

6. INSPECTION, TESTING AND ADJUSTING

- a) The Contractor shall employ the services of a specialist company approved by the Engineer regularly engaged in providing a testing balancing and commissioning service and who has been in continuous business for not less than 5 years employing fully trained staff having not less than 3 years dedicated experience.
- b) A senior experienced Commissioning Engineer with minimum dedicated experience of 5 years shall be responsible for supervising and directing the activities for the testing and commissioning team.
- c) All installations shall be inspected and tested in sections as the work proceeds and on completion as composite systems and it shall be noted that the Consultant or any of the other relevant Authorities may require to inspect or test any equipment during manufacture at the Manufacturer's works. All necessary arrangements shall be made as part of this Contract.
- d) The entire drainage and vent system and building sewer shall be subjected to testing after installation to ensure a leak-proof installation under operation conditions.
- e) All the openings in the piping system shall be tightly closed by inserting test plug so that heavy rubber gasket fits snugly all around the opening. The highest point will be left open to supply water and may be raised if necessary by temporary jointing to develop a minimum head of one pipe length of water at each section of the system. Water is filled to the point of overflow and any drop in the level of water will indicate a leak that will be found by inspection. The water level will be checked for no drop for at least 12 to 24 H. Stacks will be tested in section, starting from the top section and then connecting top section to next lower section.

7. EXTERNAL SEWERAGE & MANHOLE NETWORK

7.1. General Requirements

Pipe connections to manholes, septic tanks and percolating pits shall be made in a completely watertight and approved manner.

Pipes shall be kept clean until final acceptance of the work. Exposed ends of all incomplete lines shall be closed with wooden plugs and adequately secured at all times when pipe laying is not actually in progress.

Pipes shall be installed on a good foundation and adequate means taken to prevent settlement. Pipes laid in smooth bed as per detail drawing shall be provided with a solid uniform bearing throughout their entire length.

Pipes shall not be buried at less than 300 below finished grade for protection against mechanical damage. Pipes shall not be run closer than 1m to building bearing walls and footings for protection against building settlement.

Precautions shall be taken to protect incomplete work from floating due to storms or from any other cause. All pipe lines or structures not stable against uplift during construction shall be well braced or otherwise protected.

All completed underground lines shall be subject to the inspection and approval of the Architect / Engineer. All pipes shall be true to line and grade. The full circle of the pipe shall be visible at the manholes.

7.2. Material

The sewer collected from internal plumbing fixture shall be carried to the manholes to septic tank and from septic tank the sewer water will be sewerage treatment plant through underground uPVC class “D” Pipes.

The rain water collected from building and surface shall be drained to drain through cast iron channel, and channel through manhole the rain water pipe will be uPVC class “B” pipes (BS4514 ABS TO BS 5255) laid underground and ceiling suspended.

7.3. Installations

The drains shall be laid truly straight in line and to an even gradient.

Excavations shall be made true and even to falls. The bottoms being trimmed to correct level and well rammed. Remove mud, rock projections, boulders and hard spots and replace with approved fill material well consolidated.

Minimum width of trench shall be 300mm greater than external diameter of pipe.

Before laying, all pipes and components shall be checked for defects and joint spaces cleared of dirt.

Socketted pipes to be laid with sockets uphill.

Where lubrication of the joint is required the pipe manufacturer's recommended lubricant shall only be used.

Lay and compact bed of granular material to provide 100mm thickness over the full width of the trench. Scoop out locally at pipe sockets where socketted pipes are used. Adjust pipes to line and level and ensure that pipe barrels rest uniformly on the bedding.

Add granular side fill uniformly up each side of pipes compacting by hand.

Any trench sheeting should be lifted before the fill is compacted.

The granular material shall be compacted in 100mm layers by hand up to 100mm minimum distance above top of pipes.

Granular material shall be locally available crushed rock graded in relation to pipe size as follows:

100mm nominal size aggregate	-	100mm dia. pipes
100 or 150 mm Ditto	-	150mm dia. pipes
100 or 150 Ditto	-	200mm dia. pipes & above

During bad weather, or in wet fine-grained soils such as clays, silts or sands, it is important to prevent the trench bottom being churned up drawing work in the trench. In such cases a blanket of granular material 75mm thick laid over the trench bottom immediately after excavation, or alternatively a sealing layer of weak concrete 50mm thick, is required.

Drains below roadways, car parks and any area subject to vehicular traffic where less than 900mm of cover shall be bedded and surrounded with concrete 150 mm minimum thickness all round with provision for movement joints.

Granular fill shall be laid in 100mm layers and had compacted to a level 300mm minimum above

top of pipe followed by main backfill material placed and compacted in 300mm layers any trench sheeting being withdrawn as the work proceeds. Heavy mechanical compactors shall not be used until there is at least 300mm cover over the pipes.

8. MANHOLES

All manholes shall be constructed to the requirements of the approved drainage standards.

Inside the building manhole covers shall be bolt down airtight double seal, recessed top.

Cover and frame are to be inset concrete filled, with surface finish to match surrounding floor. All covers are to be medium duty, locking and sealed.

Covers for external manholes subject to vehicular traffic shall be kite marked, heavy ductile cast iron single seal, non rock heavy duty with square push fit seal plate. Covers to be complete with lifting key-holes, and generally constructed in accordance with BS. 497:76 and shall have a clear openings of 600x600mm unless otherwise indicated. Double seal covers shall be provided where indicated on drawings.

9. GULLY TRAPS

Where indicated on drawings provide kite-marked curb gully unit of ductile iron hinged grate, road retaining bar with clear opening size 250x250mm. Unit to be black bitumen coated and shall be designed to deter ingress and help prevent blockage. AGRP grid shall be provided as standard.

10. CHANNEL CAST IRON GRATING

Storm water channel gratings & cove shall be 600kg per/sqft. Load heavy duty ductile iron, locking and seal clear openings size 20mm horizontals cut, black / grey - epoxy coated and shall comply with BS 497 indicated on drawing or detail drawing.

11. INSPECTION OF THE WORK

- a) The representatives of the Owner and the Consultant will make periodic visits to the site during construction to ascertain that the work is being executed in reasonable conformity with all plans and specifications, but will not execute quality control at all times. Contractor must maintain the quality control as intended in the contract documents.
- b) Correct all deficiencies immediately as noted during field inspections.
- c) Request in writing that a final inspection of all services.
- d) Do not issue this written request until:
- e) All deficiencies noted during job inspections have been corrected.
- f) All systems have been balanced and tested and are ready for operation.
- g) All balancing reports have been submitted and reviewed.
- h) All instruction manuals have been submitted and reviewed.
- i) The cleaning up is finished in all respects.
- j) All spare parts and replacement parts specified have been provided and receipt of the same acknowledged.

12. CORRECTION AFTER COMPLETION

- a) Remedy all work in accordance with the General Conditions of Contract during the Maintenance period.

- b) Attend immediately to any and all the defects occurring during the period defined above and repair in a manner to prevent recurrence. This contractor is responsible for all work required by other trades necessary to repair the works of this section, or necessary to repair damage caused by the failure of any part of this section.

13. GUARANTEES

- a) The Contractor will guarantee all material and workmanship for at least 12 months after preliminary take over by the Owner.
- b) All guarantees from equipment suppliers will be vested in the Owner, regardless of whether the Contractor who supplied the equipment is still associated with the project or not.
- c) Guarantees will be full guarantees and will include all overhead, profit, incidental charges and sundries.
- d) Where damage is caused to any other item by any failure of the item guaranteed, then the guarantee shall also include the costs incurred in rectifying that damage.

14. MAINTENANCE

- a) Maintenance is defined as the Contractual Liability to maintain the equipment in working condition, PLUS the regular checks and servicing of equipment during the maintenance period, including all the consumables and spare parts to keep the equipment in best working order.
- b) Regular maintenance shall be as necessary, but in any event not less frequently than monthly. Breakdown calls shall be attended immediately.

GENERAL REQUIREMENTS OF FIRE FIGHTING SERVICES

1. GENERAL

- a) These are general requirements/specifications for the Fire Fighting Services. However, the main tender documents consisting of the Instructions to Tenderness, Form of Tender, Conditions of contract, Note on Pricing, Preliminaries Sections and any Supplementary Conditions of Contract shall be also applicable.
- b) The terms Contractor and Subcontractor used in the fire fighting documents and drawings are to be considered to mean the Contractor for firefighting works.

2. INTENT

- a) Contractor shall be responsible for proper performance of all fire fighting systems in accordance with relevant standards and codes and design parameters listed hereinafter.
- b) Provide all items, articles, materials, operations, sundries, labour, supervision, guarantees, allowances for overhead and profit, etc., to achieve a fully operateable/functionable and acceptable system.
- c) The precedence of documents and drawings shall be as determined in the Contract document. However, consider the specifications as an integral part of the work together with the drawings. Consider any item or subject omitted from one, but mentioned or reasonably implied on the other as properly and sufficiently indicated and provide the same under the work of this division.
- d) The Contractor is responsible for developing his own take off of materials and is to make this available as requested to the Consultant. It is the intent of the Working Drawings, Specification and BOQ that all work, equipment, pumps, piping work, accessories and wiring shall be provided complete, commissioned, tested, adjusted and ready for operation.
- e) The Drawings, Specifications and BOQ shall be taken as whole and not separately since they are intended to explain and illustrate each others.
- f) Any apparatus, appliance, material or work not shown on drawings but mentioned in the Specification and BOQ, or Vice Versa, then any incidental accessories necessary to make the work complete in all respects and ready for operation, even if not particularly specified, shall be provided without additional cost to the Owner.
- g) Minor details not usually shown or specified, but necessary for the proper installation and operation, shall be included in the work, and in the Contractors bid.

3. CONTRACT DRAWINGS

- a) The drawings for services works are design drawings, diagrammatic, and intended to convey the scope of work and indicate general arrangement and approximate locations of apparatus, fixtures, pipe and duct runs, etc. The drawings do not intend to indicate architectural or structural details.
- b) These cannot be used as shop drawings. Contractor must develop own detailed shop drawings for work at site.
- c) Do not scale drawings. Obtain accurate dimensions to structure and architectural items from drawings of those trades. Confirm by site measurement. Verify location and elevation of all services (ACMV, Water, Electrical, Telephone, Sanitary, Storm Drainage, Gas, etc.) before proceeding with the work.
- d) Make at no extra cost, any changes or additions to materials, and/ or equipment necessary to accommodate structural conditions (pipes or ducts around beams, columns, etc.)
- e) Alter at no additional cost, the location of materials and/ or equipment as directed, provided that the changes are made before installation and do not necessitate additional material.

- f) Install all ceiling mounted components (Diffusers, grilles, detectors, light fixtures, sprinklers, emergency lights, fire detectors, loudspeakers, camera points, etc.) in accordance with the reflected ceiling drawings which are to be prepared by the Contractor and coordinated with all trades. These must be submitted for approval and be approved before any work commences on site.
- g) Leave space clear and install all work to accommodate future materials and/or equipment as indicated and/or supplied by other division of work of the contract. Install all pipe runs, conduit runs, cable trays, etc., to maintain maximum headroom and clearances, and to conserve space in shafts and ceiling spaces and under floors, and to provide adequate space for service and maintenance.
- h) Confirm on the site the exact location of outlets and fixtures.

4. SHOP DRAWINGS, BUILDER'S WORK DRAWINGS AND MATERIAL SUBMITTALS

- a) Within 15 days of award of Contract, submit programmed of works. Along with the programmed, submit a schedule detailing proposed submission dates for all Material Submittals, Shop drawings and Builder's work drawings. Allow 15 days review period by the Consultant for each submission.
- b) Contractor must obtain, from the Consultant, approvals of all materials, equipment and drawings within appropriate time to facilitate work at site, but, within 15 days latest, from the Contract award date. This period includes any required resubmissions till final approval is obtained.
- c) Prepare shop drawings in conjunction with all trades concerned, showing sleeves and openings for all passages through structure and all insert sizes and locations.
- d) Prepare composite construction shop drawings, fully dimensioned, of piping and equipment in tunnels, shafts, mechanical equipment rooms and areas, and all other critical locations to avoid a conflict of trades.
- e) Base equipment drawings upon shop drawings and include but do not necessarily limit to, all details pertaining to access, cleanouts, tapings, sleeves, electrical connections, drains, location and elevation of pipes, ducts, conduits, etc., obtained from consultation with, and agreement of, all trades involved.
- f) Prepare drawings of equipment bases, pump pits, anchors, inertia slabs, floor and roof curbs, wall openings, trenches.
- g) Prepare all drawings to scale as agreed with the Consultant. Generally, the scale shall be 1:100 for layouts and 1:20 for Details and Sections, etc. Forward these drawings, approved by all trades concerned to the Consultant for his records. Provide copies in a number as specified elsewhere in the Contract but not less than four sets.
- h) Drawings production and presentation is a Contractual matter and any delay in making these submissions will be considered a Contractual delay and may be subject to Contractual penalties in accordance with Contract documents.
- i) The Consultant will only consider shop drawings bearing the stamp of the Contractor and all Subcontractors involved. Check for all pertinent information such as physical dimensions, make, performance, electrical characteristics and indicate the intended use and location before submitting these drawings. Use reference symbols or enumeration to correspond to the design drawings.
- j) Assume responsibility for accuracy of equipment dimensions related to space available, accessibility for maintenance and service, compliance with inspection authorities codes. Ensure that shop drawings indicate working weights of all equipment.
- k) The submission of samples, wherever required by Consultant, will be subject to the same procedure as that of shop drawings. One set of such samples shall be required to be brought to site and kept there after approval till substantial completion.

- l) The Consultant will mark the drawings "Approved / Approved with comments / Revise and Resubmit / Not Approved. Contractor shall resubmit accordingly.
- m) The Consultant is not responsible for any delays caused by the inadequacy of the Contractor's drawings or his failure to obtain initial or subsequent approval. Any time taken by the Contractor to obtain approval after the originally scheduled date will be considered as a delay to the contract caused by the Contractor.
- n) The Consultant's review shall not relieve the Contractor from responsibility for deviations from the Contract documents, unless he has, in writing, called the Consultant's attention to such deviations at the time of submission of drawings. The Consultant's approval shall not relieve the Contractor from the entire responsibility. Any approval by the Consultant shall be on the understanding that any item submitted shall be ordered with options and modifications to fully meeting the specification. Any fabrication, erection, setting out or other work done in advance of receipt of stamped drawings shall be done entirely at the Contractor's risk and cost.
- o) Furnish prints of the reviewed details to all other parties who may require them for proper coordination of their work, and furnish all information necessary for the work as a whole.
- p) Obtain Manufacturers' installation directions to aid in the proper execution of the work. Submit six copies of such directions to the Consultant prior to installation, for use in inspecting the work.

5. RECORD (AS-BUILT) DRAWINGS AND OPERATION AND MAINTENANCE MANUALS

- a) As the job progresses, mark on one set of prints to accurately indicate the status of installed work. Have the prints available for inspection at the site at all times. 30 days before commissioning, finalize the As Built drawings and submit 2 sets as draft to the consultant for checking and approval. Upon approval, submit six sets of prints and soft copies of all drawings to the consultant for onward transmission to the client.
- b) Show on the record drawings the installed inverts of all services entering and leaving the building and the property. Dimension underground services at key points of every run in relation to structure and building. Record all elevations for underground services in relation to floor level of the building and give reference datum to Municipal benchmarks.

6. OPERATION AND MAINTENANCE MANUALS

- a) Upon successful commissioning, submit one draft of Operation and Maintenance Manuals for review and approval of Consultant.

Separate binders shall be used as follows:

- Fire Sprinkler System
 - Fire Hydrant System
 - Fire Hose Reels
 - Fire Pumps
 - Fire and Safety.
 - Any Service other than above.
- b) The minimum information required is as follows:
 - Catalogs highlighting the Make, Model and other necessary details for all Material and Equipment installed.
 - List of Local Agent / Supplier for all Materials and Equipment with Telephone, Fax and Email address.
 - Detailed description of systems operation.
 - Procedures for Preventive regular and the breakdown maintenance, with Manufacturer's Operation and Maintenance Catalog for all Systems / Equipments.

- Commissioning date for all Systems / Equipment.
 - List of recommended spares.
- c) Upon approval of the draft by the Consultant, submit 4 set of manuals to Consultants for onward submission to the Owner.

7. TEMPORARY SERVICE

- a) Do not use any of the permanent service facilities during construction, unless specific written approval is obtained from the Consultant and the Owner or where specifically allowed elsewhere in the Contract Documents.
- b) In the event that mains power is not available or is not of sufficient capacity for commissioning and testing, supply, install and operate diesel generator(s) of the correct capacity at the contractor's own expense.

Any generator must have full safety features and must be maintained regularly to ensure power at site all times.

8. COOPERATION

- a) Confer with all trades to install the equipment, which may affect the work of this division, and arrange equipment in proper relation with that equipment installed under all Divisions of the Contract.
- b) Furnish all items to be built in by others, in time, complete with all pertinent information, commensurate with the progress of the work.
- c) Store materials neatly and out of the way and clean up all refuse caused by the work daily.

9. PROTECTION AND STORAGE

- a) Protect the buildings and structures from damage due to carrying out of this work.
- b) Protect all mechanical & electrical works from damage. Keep all equipment dry and clean at all times.
- c) Cover all openings in equipment and materials. Cover all temporary openings in ducts and pipes with polyethylene sheets or caps until final connection is made.
- d) The quality of such cover must be determined with due regard to how long it may be until final connection.

10. SUPERVISION

- a) The Subcontractor will maintain at site, as necessary for the performance of the Contract, qualified personnel and supporting staff, with proven experience in erecting, testing, and adjusting projects of comparable nature and complexity.
- b) Before commencing work the Contractor will submit details of the proposed Engineers and Supervisors, including copies of their Certificates. If in the Consultant's opinion the proposed Engineers or Supervisors are not adequately qualified or are otherwise unacceptable, the onus is on the Contractor to submit alternates until such approval is given.
- c) Where the Contractor's staff becomes during the Contract deficient in performance, the Contractor is to remedy the situation by immediate and appropriate replacement, to Consultant's approval.
- d) Approval of the Contractor's Engineers or Staff shall in no way prevent the withdrawal of that approval at any time during the Contract should the Consultant so desire. In the event of such disapproval, Contractor will be required to rectify the position as stated above within 14 days.

- e) In the event of any negligent or severely detrimental behavior the Consultant has the right to order the removal from site of any Engineer, Supervisor, or worker on a "forthwith" basis.

11. MATERIALS AND EQUIPMENT

- a) All materials used on the project shall be brand new. Obtain approval for all manufacturers from the Consultant.
- b) "New" is defined as newly manufactured, and delivered to site as such. Any Equipment which in Consultants opinion second hand or has been mishandled before delivery to site, shall be rejected.
- c) All materials used on this project shall bear the third party quality assurance stamp like British Standard kitemark, UL, FM, and/or other quality assurance authority as appropriate, in the opinion of the Consultants.

12. CUTTING AND PATCHING.

- a) Inform all other Divisions in time concerning required openings. Obtain the approval of the Consultant before doing any cutting.
- b) Obtain the approval of the Consultant before doing any cutting. Supporting members of any floor, wall or the building structure shall only be cut and in such a manner as approved by the Consultant. All reinstatement work must be done to the same standard as the original work.

13. INSERTS, SLEEVES, ESCUTCHEONS AND CURBS

- a) Under this section supply necessary sleeves and other inserts to other trades.
- b) Use only factory made, threaded or toggle type inserts as required for supports and anchors, properly sized for the load to be carried. Place inserts only in portions of the main structure and not in any finishing material.
- c) Use factory made expansion shields where inserts cannot be placed.
- d) Do not use powder activated tools except with the written permission of the Consultant.
- e) Supply and locate all inserts, holes, anchor bolts, and sleeves in good time when walls, floors, and roof are erected.
- f) Use the following materials for pipe sleeves:
 - Through all interior walls above grade use uPVC Class "B" 150 dia pipes, machine cut, flush with finished structure.
 - Through all exterior walls above grade use uPVC Class "B" 150 dia pipes, machine cut, flush with finished structure inside and to suit flashing on outside.
 - Through all exterior walls below grade and all other waterproof walls use uPVC Class "B" 150 dia sleeves, machine cut.
 - Pack all sleeves between the insulated pipe and the sleeve or where un-insulated between the pipe and the sleeve with loose fiberglass insulation. Seal the annular space as follows:

14. GENERAL WELDING REQUIREMENTS

- a) All welding shall be generally in accordance with ANSI B31.
- b) Tack welds shall be performed by fully qualified welders and all tack welds shall be of a length equal to twice the pipe thickness and shall fully penetrate the pipe walls.
- c) Where welding is carried out in the proximity of inflammable materials special precautions shall be taken to prevent risk of fire or other damage to the building fabric.

- d) Where oxyacetylene cutting equipment or any welding plant is being used by an operative for any of the works defined in the contract documents, then fire extinguishers shall be supplied and carried as part of the equipment. The operators of cutting and welding equipment shall be trained in the use of the fire extinguishers which they carry and all extinguishers shall be fully charged and ready for use. In all cases, extinguishers shall be positioned immediately adjacent to the position where cutting and welding is being carried out and shall be readily accessible for use in the event of an emergency.
- e) All accommodations, benches, tools, welding plant, acetylene, oxygen or electricity, filler rods and electrodes, which are necessary for installations where welding is required shall be provided as part of this contract.
- f) Welding shall not be done at a temperature of 5 degrees Centigrade or below unless the parent metal is preheated by torches or other approved means until it is warm to the hand (about 27 degrees C) for about 150mm either side of the joint. No welding shall be done below minus 18 degrees C. After preheating, the heated portion including the welded joints shall be covered with muffs or suitable insulation materials to allow cooling free from draughts. Any open ends of the pipe or assembly shall be effectively sealed to prevent heat flow by convection.
- g) All welded pipe assemblies shall be constructed so that individual welded joints do not affect each other. The distance between the centers of adjacent welds shall be not less than twice the bore diameter of the pipe.
- h) No welded joints shall be left partially completed. Any joints tacked in position must be promptly finished within the working day. The Consultant will reject all work not done in accordance with this instruction.
- i) Where work is rejected, pipes must be machine cut at least 150 mm either side of rejected welds and proper weld preparation must be used on the shortened sector. Where shorter fill-in sections are required because of such rejection and reworking, then new full sized lengths must be supplied by the Contractor.
- j) Where pipes with longitudinal seams are specified, pipe seams shall be arranged such that adjacent seams are opposed 45 deg. from each side of top dead centre and branches shall be made only with weldable fittings.
- k) All filler metals which are coated shall be protected from excessive moisture changes. Filler materials or flexes which show any sign of deterioration shall not be used. If requested by the Consultant samples of filler rods to be used shall be submitted to him for approval before any work is done on site.

These may be submitted, at the Contractor's cost, to an independent testing laboratory for verification.

15. TESTS FOR WELDER QUALIFICATION

- a) The purpose of the welder's qualification tests is to determine the ability of the welders to make sound and acceptable welds. Before any site welding on the contract is allowed, each proposed welder shall carry out the tests required in the presence of the Consultant, or the Employer's Insurance Inspector.
- b) Any weld test specimens which have been suitably marked and approved shall be kept on site by a responsible person, so that they can be produced at any time, at the request of the Consultant.
- c) All accommodation, benches, tools, welding plant, acetylene, oxygen, electricity, test pieces, filler rods, electrodes, facilities for cutting and grinding, polishing, bending and examining, which are necessary for welders qualification tests shall be provided by the Contractor. In the absence of any items for inspecting the welds, the Consultant may submit the finished samples to an independent laboratory for testing at the Contractor's expense.
- d) Under no circumstances shall a welder be employed on the contract, either on or off the site for welding operations other than those for which that welder is qualified.

- e) Copies and records of all test reports shall be promptly given to and kept by the Consultant.
- f) Even welders holding a certificate for welding are to be tested at this job site in full accordance with the specifications.
- g) Tests for Qualification on Steel Pipes
 - The Contractor shall be responsible for the quality of welding and brazing and shall provide the testing of the welders employed. Certificates of such proficiency test, together with stamped samples provided for Engineer's review before welding work is commenced. The welder's proficiency standard to be equal to Lloyd's Standard Class 2, certified by an authorized testing laboratory paid for the contractor.
 - Qualification tests will be made for butt and branch welds in pipes. One test piece per welder will be required for the qualification of welding of pipes exceeding 100mm nominal diameter.
 - In addition, test pieces will be required for each position of a pipe. These positions will be horizontal and rotated while welding, horizontal and fixed while welding, vertical and fixed while welding for each range of nominal diameters specified.

16. TESTING OF WELDED PIPEWORK INSTALLATION.

- a) Testing of welded pipe work installation shall be by either destructive or non-destructive test method.
- b) Each butt-welded test piece to be subjected to two root bend tests and two nick break tests of the welding.

Each branch welded test piece will be subjected to two root bend tests and two fillet break tests of the welding.

Each test piece weld to be radiographically examined.

- c) The Contractor shall assign an identification symbol to identify each welder and this will be used to stamp the work done by that welder.
- d) The Contractor will compile a set of safety instructions concerning welding procedures for the welders and after review by the Engineer, these will be issued to the welding operatives and foremen.
- e) The Contractor shall allow for ten percent of all the welds to be radiographically examined.

Determination of piping sections to be tested will be designated by the Engineer.

The timing of the radiographic examination of a weld or welds designated to be so examined will be confirmed in writing by the Engineer during the installation and commissioning.

Radiographic examination of welds will be carried out by a specialist employed by the Contractor subject to review by the Engineer. The specialist so employed will be responsible for the proper indexing, interpretation and reporting of the results of the radiographic tests.

- f) Any weld, whether radiographically tested or not which are considered by the Engineer to be faulty, either in whole or in part, or which have failed under hydraulic or other tests so designated by the Engineer, will be removed and replaced by the Contractor.
- g) The faulty part of a weld may be removed by flame gouging, chipping or grinding. Otherwise, the Engineer may instruct that the portion of the works containing the fault weld be cut out and replaced by the welding in of a new section of pipe or member.
- h) Should any of the welder's work (as defined by the Engineer) be found to be faulty during radiographic tests, then that welder shall be removed from site and all other welds undertaken by that welder shall be checked by radiographic means and replaced as necessary at the expense of the contractor.

- i) The extra radiography involved shall not be part of the 10% inspection previously stipulated.

17. PAINTING AND IDENTIFICATION

- a) All painting of plant, equipment, storage vessels, ducting, pipes and the like shall be carried out by an approved specialist painting contractor.
- b) Painting shall be applied to all exposed pipe work, and associated components, valves, fittings, etc., equipment, supports of any kind, insulation, plain mild steel, copper, or cast iron surfaces. Steel piping shall be painted even if to be insulated, before insulation is carried out.

18. FLUSHING AND CLEANING

- a) Flush all fluid-carrying systems after completion as specified elsewhere. Discharge the flushing fluid through all strainers and out through line sized valves with hose ends. Clean all strainers. Repeat flushing operation to the approval of the Consultant until the water is running clear, colourless and odorless and the conductivity is no more than 30 ms/cm above the mains water.

19. INSPECTION, TESTING AND ADJUSTING

- a) All the works provided as part of this Contract shall be commissioned in accordance with all relevant Specifications of relevant NFPA standards and to the entire satisfaction of the Consultant.
- b) The Contractor shall employ the services of a specialist company approved by the Engineer regularly engaged in providing a testing balancing and commissioning service and who has been in continuous business for not less than 5 years employing fully trained staff having not less than 3 years dedicated experience.

A senior experienced Commissioning Engineer with minimum dedicated experience of 5 years shall be responsible for supervising and directing the activities for the testing and commissioning team.

- c) Carry out all tests specified. Carry out all tests required by Authorities having jurisdiction. Test the equipment to the requirements of the specification and where necessary, in the presence of the Manufacturer.
- d) Provide all equipment, labour, instruments, loading devices, incidentals, and pay for all fuel, power and sundries required carrying out the tests.
- e) All installations shall be inspected and tested in sections as the work proceeds and on completion as composite systems and it shall be noted that the Consultant or any of the other relevant Authorities may require inspecting or testing any equipment during manufacture at the Manufacturer's works. All necessary arrangements shall be made as part of this Contract.

This will generally not apply to specified items unless specifically noted in these documents, but may be necessary for alternate equipment, should this be considered at all.

- f) All tests shall be arranged in cooperation with the Consultant and his Engineer and all other concerned parties and shall be subject to at least five (5) days notice in writing of the time, location and nature of the test to be performed. No test shall be considered valid unless the Consultant is present.
- g) All necessary skilled and unskilled labour shall be provided for attendance during the tests (including pre- and post- test activities,) and the test media shall be provided and subsequently disposed of except where specifically stated otherwise.
- h) The testing and adjusting is the contractual responsibility of the Contractor but actual performance of the tests is expected to be the sole responsibility of the Specialist Company.
- i) Have all testing and balancing performed by only persons who are thoroughly versed in this type of testing and balancing and with proven ability. Submit names, complete with experience records, and references for approval of the Consultant.

- j) Any defects occurring at any time during the test duration shall be made good and a complete re-test shall be carried out, all at no cost to the Contract.
- k) Where failure occurs during a test, inspection or commissioning procedure which results in damage to the building fabric and/ or any services not provided as part of this Contract, or requires subsequent builder's work to be carried out, carry out all such repair work to the entire satisfaction of the Consultant at no cost to the Owner or the Consultant.
- l) All test points shall be provided which are necessary to carry out the specified tests and commissioning procedures including facilities for measuring or monitoring temperature, pressure, pressure drop, volume flow, in-duct sound power or sound pressure, humidity, or other relevant conditions in both air side and water side systems. Such points shall be fitted with removable plugs, flanges, or other appropriate and approved devices.
- m) Prepare test report forms for each test to be performed and submit these to the Consultant at least two weeks prior to the commencement of any tests.
- n) Test only after the system installation has been completed and the system has been put into continuous operation. Perform the testing, adjusting, and balancing when outside conditions are commensurate with the design conditions for the given system. Add dummy loads to the system if outside and inside conditions are less severe than the specified points.

20. COMMISSIONING OF SERVICES

- a) All piping systems shall be flushed, chemically cleaned and then filled with treated water, or appropriate fluid, vented as necessary, and brought to operating conditions and the flows then regulated to the design values.
- b) Flow through pumps shall be measured by relating the pressure drop across the pump to manufacturers test curves. A copy of the test curve indicating the final operating point shall be forwarded to the Consultant.
- c) Sound pressure levels (dBA) shall be measured in all rooms containing supply or extract terminals, all plant rooms, all rooms immediately adjacent to plant rooms and all rooms located above or below plant rooms. The Consultant may at his discretion request a spectrum band analysis of sound pressure in any locations.
- d) All automatic controls shall be commissioned by the authorized Supplier of Controls.
- e) Fault conditions shall be simulated and all alarms and safety devices shall function correctly. Such proving tests shall be carried out in the presence of the Consultant and certificates shall be provided specifically detailing all check procedures which have been carried out.
- f) Following proving tests all installations shall be left in working order ready for handover.
- g) All electrical systems shall be tested and commissioned in accordance with IEE regulations and local authority codes.

21. SYSTEM ACCEPTANCE

- a) The ultimate condition for system acceptance is that the Owner and Consultant have inspected the system and found it to be acceptable, and indicated this in writing.

Issuance of the final payment certificate does not necessarily indicate system acceptance, neither does release of final payment holdback in whole or in part. The Consultant's acceptance may be contingent on any or all of the following if applicable:

- b) Submit original copies of letters from manufacturers of all systems indicating that their technical representatives have inspected and tested the respective systems and are satisfied with the methods of installation, connections and operation.
- c) Submit "as built" drawings and operation and maintenance manuals.
- d) Train owner's maintenance staff.

22. CORRECTION AFTER COMPLETION

- a) Remedy all work in accordance with the General Conditions of Contract during the Maintenance period.
- b) Attend immediately to any and all the defects occurring during the period defined above and repair in a manner to prevent recurrence. This contractor is responsible for all work required by other trades necessary to repair the works of this section, or necessary to repair damage caused by the failure of any part of this section.
- c) Instruct all Suppliers and Manufacturers that guarantees on equipment will commence when the completed work is accepted and not from the date the equipment is put into operation. In the event that this condition is omitted by the supplier, or if subsequent cost to the Owner is involved. Contractor shall be liable for such costs.

23. GUARANTEES

- a) The Contractor will guarantee all material and workmanship for at least 12 months after preliminary take over by the Owner.
- b) All guarantees from equipment suppliers will be vested in the Owner, regardless of whether the Contractor who supplied the equipment is still associated with the project or not.
- c) Guarantees will be full guarantees and will include all overhead, profit, incidental charges and sundries.
- d) Where damage is caused to any other item by any failure of the item guaranteed, then the guarantee shall also include the costs incurred in rectifying that damage.

24. MAINTENANCE

- a) Maintenance is defined as the Contractual Liability to maintain the equipment in working condition, PLUS the regular checks and servicing of equipment during the maintenance period, including all the consumables and spare parts to keep the equipment in best working order.
- b) Regular maintenance shall be as necessary, but in any event not less frequently than monthly. Breakdown calls shall be attended immediately.
- c) Maintenance period shall be 1 year from the date of handing over for all fire fighting works.

FIRE FIGHTING SERVICES INSTALLATION AND EQUIPMENT

1. SCOPE OF WORK

- a) The work shall include supply, installation, testing, commissioning, adjustment and setting to work of the fire fighting services installation.
- b) The contractor is to assume full responsibility for the correct functioning of the system and to carry any liability or guarantee as may be necessary to protect all parties in this regard.
- c) The fire fighting services subcontractor shall be responsible for coordination with other trades and services and shall provide all materials, labour and supervision, equipment, tools, appliance, services, etc. for carrying out the following items of works:
 - Fire Fighting installations.
 - Support and Protection of pipe work, plant and equipment installed within the contract.
 - Protective painting of all materials installed within this section of the contract.
 - Identification of all services.
 - Electrical power and control panels for power supply to equipment including cabling from panels to respective equipment. Power supply terminating in an isolating switch terminating within 3 meters of each equipment shall be provided by the electrical subcontractor.
 - All builder's work including breaking and making good of walls, floors, etc., equipment foundation pads, sleeves, etc.
 - Hoisting of heavy equipment.

2. SERVICES DESCRIPTION

- a) Reference Specifications and Standards

Where called for in the sections which follow, the equipment, material and installation shall comply with the requirements of the latest standards and codes of following and requirements of the Local Authorities:

- British Standards Institute
- British Standard Codes Of Practice
- Pakistan Standards Institute
- American Society for Testing Materials (ASTM) Specifications.
- Underwriter's Laboratories, Inc.(UL).
- American Society of Plumbing Engineers
- The Institute of Plumbing, UK
- Chartered Institution of Building Services Engineers
- National Fire Protection Authority

- b) The system shall be installed as detailed in the drawings.
- c) System Description
- d) Combined sprinkler, wet riser and hose reel system
- e) From the incoming supply shall be connected to a building RCC water storage tank of capacity as indicated on the drawings. This tank shall have enough capacity to meet the daily storage requirements of the building along with the minimum water storage requirement as recommended by NFPA.
- f) Combined automatic fire pump set (sprinkler, wet risers and hose reels) shall be installed at the sprinkler pump room.
- g) The pump set shall be consisted of one electric duty, one electric standby and one electric jockey. The combined sprinkler and wet riser system will be designed to NFPA-13 & NFPA-14 regulation.

- h) The fire pumps shall comply with NFPA – 20. Description of pipe work and controls shall be as detailed in relevant sections.
- i) Breeching inlets shall be installed at the ground floor level adjacent to main building.
- j) Fire Hose and Fire Hose Reels
- k) Fire hose cabinet with ball/gate valves, fire hose reels shall be installed within individual fire hose reel cabinet. Details of the cabinets shall be as detailed on drawings.
- l) Fire extinguishers shall be installed as shown on the drawings and as required by NFPA Standard.

3. PIPING FOR FIRE SERVICES

- a) 3.1 The piping system should be as straight as possible. Necessary changes of direction should be made with standard bends, springs or long turn fittings; elbows should NOT be used.
- b) 3.2 The piping system shall be of mild steel (MS) seamless schedule 40 ASTM-A53 grad “B” pipe and fittings with Mechanical joints with applicable pressure rating and installation shall be carried as per NFPA 13 Standard. The material shall be approved by LPCB – UK and shall be UL listed.

4. FIRE FIGHTING ACCESSORIES

4.1 Under Ground Fire Hydrant

Under ground fire hydrant outlets should be of a type acceptable to the public fire brigade and should comprise a valve 65mm bore constructed in gun metal, screwed or flanged for attachment to the riser and fitted with a 65mm instantaneous female coupling to conform the BS 336 and a blank cap secured by a suitable length of chain. The valve gate should lift clear of the valve chamber cast iron cover level as per detail drawing and the valve cover should be securely fitted to the valve body so that it does not unscrew when operated. The valve spindle should not be less than 22mm diameter and fitted with a gun metal handwheel about 150mm in diameter which should be marked with OPEN and SHUT directions; openings should be anti-clockwise. The whole fitting should be of sound construction and shall be suitable for a working pressure of 175 psi.

The valve must have an in-built integral pressure water pressure to 4.5 bar at all outlets.

4.2 Inlet Breeching Piece

The riser shall be fitted with a twin inlet breeching piece for fire brigade use in addition to the fire pumping station, as required by the local Fire Authority. The inlet shall be protected by a swing type non-return (check) valve.

The breeching piece shall comprise 2 inlets consisting of a 65mm instantaneous male coupling and bill-ten a swing type non return valve and shall be protected by a cap secured by a suitable length of chain. The coupling shall comply with BS 336.

Landing valves should be installed at a height above floor level between 750mm and 1100mm. The valve outlet should be installed to give the following clearances: not less than 150mm on both sides handwheel 200mm clearance above the both side.

4.3 AIR VENTING

Automatic air vent (eliminators) shall be provided at discharge water header for firefighting system and as shown on drawings.

Air vents on fire fighting systems shall be of float type, air eliminator of approved manufacture, plant room. Air vents shall be suitable for the system pressures and temperatures. An air release pipe shall be connected to the air outlet and taken to the nearest suitable discharge point.

4.4 PUDDLE FLANGES

Where pipe work passes through the external walls of the buildings or u/g. tank below ground level, the Contractor shall supply and cast or build puddle flanges into the structure.

Puddle flanges are to be manufactured from the same material as the pipe work of which they form a part.

Each puddle flange shall comprise a length of pipe, flanged or screwed at each according to diameter with an un-drilled slip-on flange welded on the outside at a point where it will be located mid-way in the thickness of the wall. The puddle flange is to be painted externally with two coats of bituminous paint before being built into the structure.

4.5 HOSE RACK CABINETE

Provide and install fire hose rack cabinet constructed from 16SWG galvanized or mild steel sheet, powder coated to post office red colour according to BS 18 B 25. Cabinet shall have a minimum size of 600mm wide x 800mm high x 150mm deep, and shall have a full glass door.

Fire hose reel shall be in a cabinet where applicable with a cabinet and door and trim. Door to be marked conspicuously "FIRE HOSE CABINET".

The size of the box or cupboard shall be sufficient to provide ready access to equipment for immediate use when required, hose running freely from pivoting pin rack and valve turned on or off easily.

4.6 Fire Hose Reels

Each hose reel shall be of the swinging pattern type with manual operation after unwinding a short length of hose and shall be housed in a cabinet, for recessed installation.

The hose should be of 25mm internal diameter rubber fire hose reinforced with double braiding and 30 m long. The nozzle shall be of high impact plastics, jet spray/shut off.

Brief operating instructions should be clearly displayed on or by each hose reel e.g. "TO OPERATE - 1) RUN OUT HOSE 2) TURN ON LOCK AT NOZZLE".

The hose reels shall be suitable for working pressures up to 3 bar (45 lbs/sq. inch) and shall be installed in accordance with the manufacturer's instructions.

4.7 Fire Extinguishers

Dry chemical powder and CO2 fire extinguishers will also be provided the fire hose cabinet expose side.

5. AUTOMATIC COMBINED SPRINKLER AND WET RISER PROTECTION SYSTEM

5.1 General

The design of the sprinkler system indicated on the drawings will be fully developed by the contractor strictly in accordance with the negotiations and requirements of the latest NFPA – 13 and NFPA - 14 regulations and the requirement of local fire officer whichever is stringent

The fire fighting system shall be fed from the underground storage tank located inside the building, which shall be constructed in reinforced concrete.

The system shall be complete with automatic packaged fire pumping station and valves, water motor alarm and gong, pressurized water mains, main distribution pipes, distribution pipes, range pipes, hangers and supporters, sprinkler heads and main drain system. The alarm panel in order that the alarm bells in various locations can be actuated.

The water motor alarm and gong should consist with a simple water turbine having the shaft connected to a rotary ball clapper mounted within a domed gong. The test valve shall be incorporated on a branch pipe from the alarm valve to allow operational conditions to be

simulated for test purposes. Auxiliary pressure sensing devices shall be incorporated in the feed to the alarm gong to actuate the main fire alarm panel.

Water from the test valve shall be properly drained. The alarm system shall be self winding, adjustable recycling non thermal type and equipped with signal retarding device to prevent false alarms due to surge in the water system.

5.2 Description

Combined sprinkler and wet riser fire protection system shall be installed with the capacity of pumps as scheduled on the drawings.

Main pump and the jockey pump shall be electric driven and the standby shall be diesel engine powered.

The pumps shall be in compliance with NFPA – 20 Standards.

The common pump outlet shall be branched at the header of the pump outlet to serve the sprinkler system and wet riser system.

The sprinkler main shall be provided with alarm gong valve. The main shall be branched to each floor. Zone control valves shall be installed for each floor branch. Zone control valves are interconnected to flow switches. Upon getting signal from flow switch the fire pumps will start and simultaneously signal will be annunciated at fire alarm panel.

Wet riser main shall be branched at each floor within cabinet.

5.3 Installation Control Valves

The system shall be provided with a set of installation control valves, main stop valve, alarm valve and test valve. The main stop valve should be strapped and double padlocked in the open position.

The alarm valve should be closed in the static position with the pressure below and above the valve, at normal level and no water flow. In the event of a pressure drop above the valves due to activation of a sprinkler head, water is admitted to the branch pipe connected to the water motor alarm and the gong.

5.4 Sprinkler Heads to be as shown on the drawings and as follows:

For false ceiling area, the pendant type sprinklers head with glass bulb rated for 680 C (155 F) shall be provided. For other areas up-right sprinkler head with glass bulb rated 680C shall be installed. These shall be located such that there is no interference with the discharge pattern and 75-150 mm below ceilings. For exposed location

- 5.5 The sprinklers and lines shall not be spaced too close together, in order to prevent an operating sprinkler from wetting and thereby delaying operation of adjacent sprinklers.
- 5.6 In locations where sprinkler heads are liable to be operated or damaged by accidental blows, they should be protected by stout metal guards, care being taken to ensure that the normal operation of the sprinkler head in the event of fire is not thereby impeded.
- 5.7 The contractor shall supply adequate quantity of spare sprinkler heads of the correct temperature rating to the employer for use during an emergency.
- 5.8 Main Pump and Standby Electric Motor Driven
- 5.9 Type - the pump shall be UL listed, FM approved in compliance with NFPA-20.
- 5.10 Pump shall be of the horizontal type end suction case made of cast iron, free of foundry imperfections and other detrimental defects.
- 5.11 Impellers shall be of bronze, of the enclosed type, statically balanced. They shall be adjustable horizontally by means of an adjustable nut located on top of the driver.

- 5.12 Pump shaft shall be of polished stainless steel and shall be supported by bearings above and below each impeller.
- 5.13 The pump seal shall be mechanical type.
- 5.14 Motor – shall be drip proof, 2900 RPM and shall be especially selected for quiet operation. The horse power of the motor shall be of such a size as to insure none overloading of the motor through the capacity range of the pump.
- 5.15 Installation – A concrete base 8 inches higher than the surrounding floor shall be provided. Construct base and install as shown by the detail on the drawings. Provide a minimum of four ½" anchor bolts from concrete to pump base.
- 5.16 Controls – The pump shall be controlled by a combined manual and automatic across the line type fire pump control panel. The control panel shall have an externally operated circuit breaker, a pilot light to indicate when power is on, switches or push button for manual or automatic operation, a pressure switch control for automatic operation and a remote alarm signal when pump is operating. The entire control panel shall be factory assembled in a steel cabinet. The panel shall have provision for connection to the BMS. Controllers to have auto-program for start/stop for future periodic maintenance.

5.17 Jockey Pump

- a) Type - The jockey pump shall be of vertical turbine type, especially designed and constructed for quiet operation. Pump shall comply with NFPA – 20.
- b) Pump - The jockey pump shall be bronze fitted, directly coupled to its motor. The pump shall use a mechanical rotating type carbon seal and shall face against a Remit insert. The pump shall be equipped with oil lubricated bronze sleeve bearings for smooth and quiet operation.
- c) Motor - shall be drip proof, 2900 RPM and shall be especially selected for quiet operation and shall be so stamped. The horse-power of the motor shall be of such a size as to insure non-overloading of the motor throughout the capacity range of the pump.
- d) Base - Shall be of a size suitable for the pump, motor, and shaft, and shall be constructed of cast iron or welded steel.

Controls - the jockey pump shall have a relief valve set for the proper pressure and a pressure switch for automatic operation. There shall be a magnetic across-the-line starter with "Hand-Off-Automatic" selector switch in cover provided to start and stop the pump.

6. DIESEL ENGINE PUMP & ACCESSORIES

- a) The engine shall be of the four stroke, compression ignition, mechanical injection type Turbo-charged, water-cooled, capable of operating continuously on full load at site elevation for a period of six hours.

The engine shall be equipped with the following methods of starting:

Automatic by means of a pressure switch through a battery powered electric starter motor.

Manually activated electric starter motor.

Manually cranked stating.

Each starting arrangement shall have its own separate relay system and set of batteries but the same starter motor shall be used for automatic or manual starting. The engine will continue to run until shut-off manually. The stop control shall be so arranged so that the engine shutdown mechanism returns automatically to the starting position after use.

The pump-engine connecting flexible coupling shall be so designed that either the pump or engine can be removed without disturbing the other. All rotating parts shall be guarded.

Engine shall be complete with: A. 24 volt electric starting equipment comprising **starter motor**

Two sets of lead-acid batteries mounted on the base plate, each adequate for 12 cycles of cranking a cold engine at 4°C.

Battery leads and connectors.

Hydrometer, to enable the state of charge of the batteries to be determined.

Two manual emergency start switches

Alternator 24V

b) A fuel system comprising

Fuel tank of sufficient capacity to allow the engine to run on full load for 6 hours.

This shall be fitted with sludge and sediment trap, special fuel level gauge and an inspection and cleaning hole. Fuel feed pipe valve with facility for locking in the open' position and interconnecting flexible fuel supply pipe shall be provided.

Fuel pump with mechanical governor & over-speed switch

Fuel solenoid actuator energized to stop

Fuel and lubricating oil filters

c) An exhaust system comprising

Flanged exhaust silencer (industrial duty)

Flanged flexible exhaust connector (stainless steel)

Mild steel exhaust pipe as required for appropriate exhaust outlet.

Protected exhaust manifold (insulated)

d) An engine cooling system comprising of the following

Cooling system with mounted heat exchanger & circulating pump.

Expansion tank

Thermostat & piping

Engine jacket heater 400V, 1kW with thermostat (if required)

e) Instrumentation

Instrument panel containing oil pressure gauge, water temperature gauge, tachometer, hour-meter and ammeter.

All necessary switches for cooling water temperature high, lubricating oil pressure low, etc.

Magnetic pick up for tacho drive

f) Spare Parts and Tools

Spare parts and tools necessary for two years operation, as recommended by the manufacturer, shall be provided as a part of the contract for the engine. A list of these spares shall be included in the offer.

7. IDENTIFICATION SIGNS

Drain valves, test valves, control valves, shall be fitted with approved enameled signs indicating their use.

8. TESTING

General : All testing shall be performed under the work of this Section. All services required for testing shall be a responsibility of the work of this Section. The contractor shall notify the Engineer of all tests, 48 hours prior to testing.

The Fire Protection Piping Systems shall be tested hydrostatically for not less than 2 hours at 1.5 times the maximum system pressure.

If the systems are tested in sections, the connection to the previously tested section shall be included.

All tests that may be required by the local Fire Authorities shall be performed under the work of this Section in the presence of their representative if so required.

All leaks shall be corrected and the system re-tested until no leaks are found, at no cost to the Owner.

When the various systems are completed, operation tests shall be run on all equipment to demonstrate proper operating conditions. These tests shall be run under the observation of the Engineer.

Cost to repair any damages to the building construction occasioned by pipe leaks or defective materials shall be borne under the works of this Section, at no cost to the Owner. All corrective work shall commence immediately after damage occurs.

9. OPERATING INSTRUCTIONS

Upon completion and approval of the systems, this Contractor shall provide an experienced engineer to instruct the Owner's operators in all details of operating and maintaining the system. The Contractor shall provide three (3) sets of type written operation instructions, parts lists and service manuals of all equipment, wiring diagrams, control diagrams and test reports, suitably bound.

10. FIRE STOP SYSTEM

10.1 Summary

Applications of fire stop systems include:

- Penetrations for the passage of cable, cable tray, conduit, piping, electrical busways and raceways through fire-rated vertical barriers (walls and partitions), horizontal barriers (floor/ceiling assemblies), and vertical service shaft walls and partitions.
- Openings and penetrations in fire-rated partition or walls containing fire doors.
- Multiple electrical boxes located within the same stud cavity.
- All materials shall conform to relevant North American or European Standards.

10.2 Definitions

Fire stopping: Material or combination of materials used to retain integrity of fire-rated construction by maintaining an effective barrier against the spread of flame, smoke, water and hot gases through penetrations in fire rated wall and floor assemblies.

10.3 System Description

Performance Requirements: Provide fire stop systems that have been manufactured and installed to maintain performance criteria stated by manufacturer without defects, damage or failure.

10.4 Submittals

- General: Submit listed submittals in accordance with Conditions of the Contract and Submittal Procedures Section.
- Product Data: Submit product data including manufacturer's SPEC-DATA product sheet, for specific products.
- Shop Drawings: Submit shop drawings showing layout, profiles and product components.
- Quality Assurance Submittals: Submit the following:

Certificates: Product certificates stating that materials comply with specified performance characteristics and physical requirements.

Manufacturer's Instructions: Manufacturer's installation instructions.

HVAC WORKS

ACOUSTIC INSULATION

Low velocity supply air ducts shall be provided with acoustic insulation for a distance of 15 linear feet from the fan discharge. Ductwork sizes shown on the drawings are net clear sizes and wherever acoustic insulation is to be supplied internally to the ductwork, the contractor shall suitably increased the duct sizes.

Acoustic insulation shall consist of semi-rigid bonded board of glass-fiber, coated with black pigmented fire resistance coating on the site facing the air stream. The coating shall resist erosion up to 5000 FPM. Air velocities.

The insulation shall have a flame spread less than 25 per ASTM E 84-75. It shall have the following sound absorption characteristics per ASTM C 423-66.

	Octave Band Center Frequency Hz.						
	125	250	500	1000	2000	4000	NRC
Thickness	Sound Absorption Coefficients						
1 "	.13	.51	.46	.65	.75	.95	.60
2 "	.25	.73	.94	1.03	1.02	1.09	.93

Application shall be per "Duct Linear Application Standard" published by the sheet metal and Airconditioning Contractors Association USA (SMACNA). All portions of ducts designated to receive duct liner shall be completely covered with Duct liner boards. Transverse joints shall neatly butted and there shall be no interruptions or gaps. Board shall be cut to assure tight overlap corner joints. The coated surface shall face the air stream. The duct liner shall be adhered to the sheet metal duct with 100% coverage of adhesive. All exposed leading edges and transverse joints shall also be coated with adhesive. In addition, mechanical fasteners shall be used to secure the duct liner board.

Adhesive shall be specially formulated for this specific application and the contractor shall ensure the prior approval of the adhesive by the Project Manager.

Fiber glass sound absorbing liner shall be of manufacturer's specified elsewhere in these documents.

The tenderer shall give complete technical details and manufacturer's technical bulletins for the acoustic insulation offered.

AIRCOOLED WATER CHILLER

1. Hermetic electric motor driven screw compressor type water chilling units, Refrigerant R- 407 or HFC Refrigerant, air cooled, complete with all automatic, capacity and safety control and accessories.
2. The minimum capacity of the units shall be as given in the schedule of equipment.
3. The unit completes with all control and accessories shall be constructed to comply with the requirements of material and workmanship according to the latest ASME Codes. The unit to also comply with the latest American Standard Safety Code for mechanical refrigerant of equipment. The complete unit should be of weather proof design and construction to be suitable for outdoor installation.
4. Unit of 17 TR capacity and above shall have minimum two independent refrigeration systems comprising hermetic type compressor motor sets, reduced voltage type motor starter, direct expansion type water chiller, air cooled condenser, automatic capacity control and safety devices, instruments, necessary refrigerant piping, initial and operating charge of refrigerant, compressor oil charge and all the other controls and devices which may be required for proper operation.
5. The compressor shall be hermetic, screw type with all rotating parts statically and dynamically balanced. The compressor shall have forced feed lubrication, oil filter, crankcase oil sight glass, crankcase oil heater, suction gas strainer and suction and discharge refrigerant stop valves. Compressor suitable for operation with the specified refrigerant and its speed not to exceed 2900rpm. Compressor motor to be gas cooled, squirrel cage type with automatic starter. Single phasing prevented, Phase reversal device necessary auxiliary contacts for electric interlocking. Sequence control, time delay relay and selector switch shall be provided to prevent the compressor from starting simultaneously and to enable to operator to prevent to interchange the lead and lag units. The compressor to have high and low pressure cutout, high temperature cutouts, anti-freeze thermostat and time delay device to permit unloaded starting.
6. The evaporator shall be direct expansion type, of ample size to given the required capacity and evaporating temperature not below 1⁰ C, factory insulated and covered with steel sheet jacket, working pressure 16 bar on refrigerant side and 10 bar on water side.
7. The air cooled forced draft condenser shall have aluminum finned copper tube coil, of ample surface area to meet the specified capacity requirements and suitable for required working pressure (minimum 23 bar) on refrigerant side. The condenser should preferably have liquid sub cooling arrangement. The condenser to have side air inlets over the coils and propeller or axial type fans with direct coupled totally enclosed fan motors and hot air to discharge upward. Fans selected for quiet operation. In case of Karachi and other coastal locations the condensers shall either be of copper tubes with copper fins or the aluminum fins shall have factory applied protective coating against corrosive action of saline atmospheric air. The tenders shall furnish detail of protective coating and conform the manufacturer's warranty period in years.
8. The unit shall be provided with suitable size refrigerant solenoid valves, pressure relief valves, charging valves, sight glasses, liquid line strainer – drier and expansion valves and other accessories as per manufacturer standard.
9. The unit shall be supplied with necessary pressure gauges and thermometers on the inlet and outlet sides of chilled water, refrigerant suction and discharge pressure gauges, oil pressure gauge and ant vibration isolators for the foundations. (If required)
10. The unit shall be supplied with flow switch in the chilled water circuit as a safety cutout to stop the unit or not to allow startup without chilled water flow. The flow switch shall have an adjustable about 5 second time delay relay in series to prevent any false stopped due to passing air bubbles in the water piping.
11. The unit should be capable of continuous operation and it should operate fully automatic after it has been started and automatically adjust the output according to the cooling requirements and maintain leaving chilled water at the specified temperature. The automatic capacity control actuated by leaving chilled water temperature should be in multi steps according to numbers of compressor.

12. Each unit should operate, stop and restart automatically after it has been started and it should automatically adjust its output to the cooling requirement without necessity of manipulation by the operator. The capacity control should be microprocessor as specified elsewhere. The unit control system should ensure trouble free start-up without overloading when the inlet initial entering water temperature is up to 30°C.
13. Operational controller of chiller shall have “LCD” display with back light and will show operational parameter of chiller i.e. chilled water temperature, ambient temperature etc.
14. In case of 2 or more units operating in parallel, microprocessor controller shall be provided so that output all units is controlled simultaneously.
15. The unit control centre would be of such design that in case the unit is stopped by any safety control, the unit shall not restart without manual reset by the operator after detection and rectification of the fault.
16. The complete water chiller unit with all controls and accessories shall comprise one factory assembled package ready for installation and factory wired to the extend possible to minimum the external wiring required at site.
17. The unit shall be supplied complete with one set of essential spare parts for year’s operation including one spar charge of refrigerant and two spare charges of oil.
18. The electric supply shall be 400 \pm 10% volt, 3phase 50cycle AC with 230 volt, 1-phase supply for control circuit only.
19. An engineer authorized by the manufacture or factory trained shall supervise the commissioning of the unit and given instructions at site to the employer’s operating for operation, servicing and maintenance work of the unit for a period of at least one week.
20. The chillers shall be of Carrier/ Dunham Bush / Hitachi/ McQuay / manufacture or approved equal.

AIR DEVICES

1. SCOPE

Supplying, fixing, furnishing, balancing and testing of Diffusers, Registers, Grilles & Louvers of different types and capacities as per drawings, specified herein and instructed by Consultant.

2. DESCRIPTION

- i). Diffuser, grilles and registers shall be factory fabricated constructed and shall distribute the quantity of the air specified, evenly over space intended without causing noticeable drafts over an air velocity of 50 F.P.M. in occupied zone or dead spots anywhere in the conditioned area. The contractor shall be responsible for correct diffusion, spread, drop, and throw. If according to the certified data of the manufacturer of the proposed units, the sizes indicated will not perform satisfactorily, the units shall be re-selected at no extra cost to perform quietly and effectively in accordance with the manufacturer's recommendations as approved by the consultant. A schedule of all air inlets and outlets indicating location, type specified air quantity, neck of face velocity, sound power level valves, pressure drop, throw and drop for registers, and maximum and minimum diffusion range shall be submitted for approval. The inlets and outlets shall be sound rated and certified in accordance with Equipment Test Standard 106 2R2 of Air Diffusion Council in sound power levels; decibels reference 10 – 12 watts, in octave bands 2 through 8. Diffusers and registers shall be provided with volume control and accessible operator. After the system is in operation, if excessive noise, draft, or dead spots, are noticeable in the conditioned spaces due to improper selection of type and size of diffuser or grille. The unit shall be changed to the proper size and type without additional cost.
- ii). Diffusers shall be furnished with anti smudge device, unless the diffusers unit minimizes calling smudging through design factors. Sponge rubber gasket shall be provided between ceiling and surface mounted diffuser or anti smudge ring. Duct plenum connecting the duct to diffuser shall be air tight and shall not be interfered with volume controller.
- iii). Grilles and registers shall be four-way directional- control type except that return and exhaust grilles may be fixed horizontal or vertical louver type. Each register shall be provided with removable key operated opposed-blade volume-control damper, Registers and Grilles shall be provided with sponge rubber gasket between flange and wall or cabinet, or ceiling. Four-way directional control shall be achieved by individual adjustment of horizontal and vertical vanes.
- iv). All diffusers, registers and grilles to be installed in fire rated walls or ceilings shall have one-hour rated fire dampers.
- v). All diffusers, registers and grilles shall handle the air quantities shown on the drawings at rated noise levels not to exceed the Noise Criteria Curve ratings shown below:
 - a. Less than NC 30 for classroom, private offices, conference rooms, libraries, Residences, tape rooms and audio- visual rooms.
 - b. Less than NC 40 for large offices, corridors, storage rooms, supply rooms, tea rooms and dining rooms.
 - c. Less than 50 for shops, repair and maintenance areas, mechanical rooms and Generators room.
- vi). All diffusers shall be insulated directly to the supply air duct & shall be so installed that the collar shall be flush with ceiling. Gasket shall be used to prevent leakages.
- vii). Registers and Grilles on side wall shall be fixed on wooden frames provided with anti termite so lignum treatment.
- viii). Plenum for linear diffuser shall be fabricated for linear diffuser using 20 gauge G.I. sheet metal. Plenum shall be provided with hanging holes at every 1200 mm center, intake round spigots at 1200 mm center unless otherwise indicated on drawings, arrangements for fixing linear diffuser without visible screws & assuring leak proof fitting into the plenum.

- ix). The louver shall be provided with insert screen, so installed as to removable for cleaning & replacement.
- x). The blade & frame of exhaust & intake air louvers shall be of heavy gauge extended aluminum section provided with powder coating.

AIR FILTER

01. Each air system shall have its own air filters.
02. The air filters shall be of type, efficiency classification, cfm capacity and sizes as given in the Schedule of Equipment.
03. The unit air filters shall be permanent, cleanable, high velocity, viscous oil type using a media composed of corrugated strips of screen wire of sheet metal placed on edge to the airflow. The corrugations shall be tapered to form a series of pyramid shaped pockets to prevent dust laden air from drifting through the filters. Expanded metal shall be placed on both sides of cleaning media to add strength and for mechanical protection. The filters shall be selected for face velocity not exceeding 450 fpm. The initial resistance shall be less than 3 mm wg.
04. the unit filters shall be mounted in air tight preferably flat otherwise angular filter box of galvanized steel or aluminum sheet so that they can be removed from either end for replacement and cleaning.
05. Medium and high efficiency filters shall have 50 %, 60 %, 80 % or 90 % average atmospheric dust spot efficiency with ASHRAE Standard 52-76 test method and ARI certified. The air filters of efficiency and sizes as specified in the Schedule of Equipment shall be installed as shown in the drawings. The air filters shall be extended surface pocket type consisting of galvanized steel holding frame and replaceable filter. The frames shall be pre-drilled for convenient assembly into banks. The frames shall be serviceable from either end. The galvanized steel holding shall be of 2" nominal depth with gasket and integral spring type latches to securely hold the filters against the gasket. The air filters shall consist of a rigid rust-resistant metal header to which individual pockets of filters media are attached. The media shall be made from fine glass fibers and scrim backing on the air leaving side. The filters shall be selected the maximum face velocity of 400 fpm. The initial resistance shall be 8mm wg and final resistance 25 mm wg. The air filters shall be AAF Dri-pak or Farr HP-100 or 200 or approved equal.

HEPA filters shall have 95 %, 99 %, 99.5 % 99.9 %, 99.97 % or 99.99 % minimum efficiency with 0.3 micron DOP smoke particles test method in accordance with MIL-STD-282 and Federal Standard 209b and to have UL586 label. The air filters of efficiency and sizes as specified in the Schedule of Equipment shall be installed as shown in the drawings. The filters to be of Panel type construction with pleated water proof fire retardant filter media of sub micron glass fibers of a design to allow air flow with minimum resistance. The pleated panels to be assembled as a multiple V-bank arrangement with media packs completely sealed within metal sides with fire retardant epoxy. The filter shall withstand 120° C continuous temperature. The filters shall be supplied complete with neoprene rubber gaskets and galvanized steel holding frames with clamping device to ensure perfect filter seal. The frames to be suitable for single or multiple filters installation. 95 % efficiency filters Shall be selected at maximum face velocity of 400 fpm and 99% and above efficiency filters at maximum 300 fpm. The initial resistance shall be 18mm wg and maximum final resistance 75 mm wg. The air filters shall be AAF type Astrocel or Farr Type Magna media or approved equal.
07. The medium or high efficiency or Hepa filters and holding frames shall be of construction that filters can be serviced / replaced either from dirty or clean air side as shown in the drawings.
08. The contractor shall supply two additional sets of medium or high efficiency or Hepa filters as spares for each air system.
09. The contractor shall install a multi-blade damper in the plenum of each air system having medium or high efficiency or Hepa filters to balance the air system when the filtering media is new with low air resistance.
10. In selecting the sizes of the air filters the air filters the space available in the plant room and airhandling unit or air system plenums should be kept in view.
11. All banks of air filters shall be provided with a manometer with inclined scale, installed across the filter bank to indicate the air resistance pressure drop across the air/filters. Each bank of medium or high efficiency or Hepa filter shall be two manometers, one across the air filters and the

second across combination air filter and balancing damper. The manometers shall have scale range of 0-15 or 0-40 or 0-8 or mm wg according to filter classification.

12. The air filters supplied under this section shall preferably be of one manufacturer.
13. The air filters shall be of American Air Filter/Cambridge/Farr/Vokes/ Air flow manufacture or equal.
14. The tender shall give following information for each type of air filters.
 - (a) Size capacity in cfm, face velocity and velocity through filtering media.
 - (b) Initial and average operating air resistance in mm wg for unit type filters.
 - (c) Initial and recommended final operating air resistance in mm wg for medium or high efficiency or Hepa air filters.
 - (d) Overall dimension of each filter bank and operating weight.
 - (e) Manufacturer's performance Guarantee Certificate and technical bulletins.

AIR HANDLING UNITS

1. GENERAL

1.1 Quality Assurance

Furnish Single / Double skin Central Station Modular Air Handling Units of type, size and capacity as set forth and called for in the equipment schedules. Units shall be constructed to comply with the requirements of material and workmanship according to the latest ASME Codes or equivalent. Units shall be tested before dispatch and ready for installation, and their performance certified in accordance with ARI standard 430 or equivalent.

1.2 Components

The units shall be complete with insulated casings, water proof insulated drain pan(s), coil(s), fan(s), motor and starter, adjustable motor and fan drives, V-belts, belt guards, filters ,dampers as required, access doors, mixing box(es), vibration isolators and all other items necessary for satisfactory operation.

2. COMPONENT FEATURES

2.1 Unit Casing

a) General Construction

Unit shall be constructed of a complete frame with removable panels. Removal of side panels must not affect the structural integrity of each module. The casing must be able to withstand up to 6 in. (150 mm Aq.) positive or 4 in. (100 mm Aq.) negative static pressure. All exterior wall panels shall be made of minimum 18 gauge G90 galvanized steel. Closed- cell foam jacketing shall be provided where modules are joined to ensure that no thermal bridge occurs.

b) Base and Frame:-

The unit base and upper frame shall be hot dipped galvanized.

c) Wall Construction:-

Units shall be double-wall constructed to prevent fiberglass erosion into the airstreams and to allow cleaning of the unit interior. Interior wall shall have minimum insulation of 1 in. (25mm) thickness and be of minimum 20-gauge solid plate galvanized steel.

Double-wall units shall be factory insulated with insulation of minimum density 1½ lb/ft³ (24 kg/m³) insulation. The insulation thickness and density is to be selected by the manufacturer to ensure that the following minimum criteria are met:-

Heat Transfer Coefficient	:-	0.20 Btu/h·ft²·°F (1.15 W/m²·K)
Noise Attenuation Characteristics	:-	As per table below

Frequency (Hz)	63	125	250	500	1 k	2 k	4 k	8 k	Overall
SPL (DB)	11	11	15	25	26	27	27	27	<30

No condensation to occur on unit Exterior when air around unit is at	:-	100°F (37.78°C) and 65% RH
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All connecting channels shall also be insulated to prevent sweating.

d) Drain Pan

Units shall have an insulated, double wall galvanized drain pan under cooling coil section(s) for drainage of condensate. Minimum insulation requirements for the drain pan are as

detailed in the section on 'Wall Construction'. Drain connections are to be provided on both sides of the unit.

e) Access Doors and Panels

Full sized hinged removable double-wall access doors with two step safety handles shall be provided for quick access to the interior of the unit casing. Doors attached by screws or doors not continuously jacketed are not acceptable. All doors/panels shall be sealed with closed- cell foam jacketing.

f) Spacer

Each unit shall be provided with a 6" (150 mm) spacer section installed where scheduled.

g) Marine Light

A marine light shall be provided on fan and access modules where scheduled.

h) Paint

Units shall be finished with two coats of baked enamel/powder coating.

2.2 FANS

a) General

Fan(s) shall be rated in accordance with AMCA Standard 210. Fan(s) shall be indirectly connected with V-belt drive and selected to produce the capacity required at the static pressure indicated.

b) Type

Fan(s) shall be of the fully enclosed centrifugal type, double width, double inlet, forward curved, Class I; or backward inclined, Class I or II; or airfoil, Class I or II. Fan(s) shall be statically and dynamically balanced.

c) Housing

Fan housing shall be constructed of heavy gauge steel equipped with intake cones designed for smooth air flow. Fan discharge shall be connected to cabinet through a 6 in. (150 mm) deep canvas flexible connection

Housed fan performance shall be certified as complying with ARI Standard 430-89. Centrifugal fans shall be dynamically balanced at the factory as a complete fan assembly (fan wheel, motor, drive and belts). Fan shafts shall not exceed 75 percent of their first critical speed at any cataloged rpm.

d) Drive

Drive assembly shall consist of a solid steel turned, ground, polished and greased shaft with heavy duty, self-aligning, re-lubricatable ball bearings. Bearing grease zeros shall be extended to fan drive side.

V-belt drives shall be designed for not less than 150 percent of the connected driving capacity. Sheaves shall have at least two grooves, selected to drive the fan(s) at the specified RPM. Motor sheave shall be of the fixed (or adjustable) type.

Units of over 20,000 CFM (34,000 m³/h) shall be provided with a totally enclosed galvanized expanded metal belt guard. The belt guard shall be rigidly attached to the bearing support structure and have a two-piece removable front panel. A teach hole shall be provided opposite the fan shaft. The belt guard shall be a universal size to accommodate any applicable drive.

e) Bearings

Fans shall be equipped with self-aligning, anti-friction pillow block bearings with a minimum life of L-50 200,000 hours. Bearings shall be equipped with grease lines allowing for lubrication from one side of the fan.

f) Motors

Fan motors shall be Totally Enclosed Fan Cooled (TEFC) motors, foot mounted (B3) 4 pole , protection class IP54, insulation Class 'F' , rated for temperature rise of 176oF (80oC),3 phase. Motor terminals to be arranged for DOL starting upto and including 5.5 KW and Star Delta start for sizes 7.5 KW and above.

g) Acoustic performance

Minimum acceptable fan/AHU acoustic performance shall be as indicated in table below:-

Frequency (Hz)	63	125	250	500	1 k	2 k	4 k	8 k	Overall
Fan Lw (DBA)	55	67	75	80	80	78	74	67	85
AHU Lw(DBA)	54	65	69	72	71	65	54	44	76
SPL * (DBA)	43	54	58	61	60	54	43	33	65

* Sound Pressure computed at 3.28 feet (1.0 m), in free field space

2.3 COILS

a) General

Coils shall be manufactured by the same company as the supplier of the air handling unit. Coils shall be designed with aluminum plate fins and copper tubes.

Fins shall have collars drawn, belled and firmly bonded to the tubes by means of mechanical expansion of the tubes. No soldering or tinning shall be used in the bonding process. Coils shall be mounted in the unit casing to be accessible for service and can be removed from the unit either through the side or top. Capacities, pressure drops and selection procedure shall be certified in accordance with ARI Standard 410.

b) Water Cooling Coils

Water Cooling Coils shall be supplied where scheduled and shall conform to the following minimum specifications:-

- Coils shall be designed to operate at 250 psig (17.5 bar) design working pressure and up to 300oF (148.9oC). Coils shall be tested with 325 psig (22.75 bar) compressed air underwater.
- Coil circuiting shall provide free draining and venting when installed, counter flow of air and water, with water velocities not to exceed 7FPS (128 m/min) and without exceeding the water pressure drops scheduled.
- All coils shall be enclosed in a coil section. Coil headers and U-bends shall not be exposed.
- All coils must have same end connections regardless of the number of rows deep.
- Coils shall have a supply header to ensure distribution of cold water to each tube of coil. Headers shall be either round copper or cast iron. Steel pipe headers are not acceptable.
- Tubes shall be ½ in. (12.7 mm) or 5/8 in. (15.875 mm) OD.

3. FILTERS

3.1 General

Air handling units are to be supplied complete with filters as scheduled, and having the following minimum specifications:-

3.2 Throwaway Filters

These filters shall be of the throwaway type and shall have 2 in. (50 mm) thick fiberglass media contained in a rigid frame. Filters shall have a rigid supporting maze across both the entering and leaving faces of the media. Filters shall be sized so as not to exceed scheduled face velocities.

3.3 Pleated Media Filters

These filters shall be 2 in. (50 mm) thick non-woven cotton fabric, treated with adhesive and continuously laminated to a supported steel wire grid. Filters shall have a rated average dust spot efficiency of not less than 25 to 35 percent when tested in accordance with ASHRAE 52-76 atmospheric dust spot method.

3.4 Permanent Filters

These filters shall be 2 in. (50 mm) thick, all metal viscous imprisonment type, capable of operating up to 600 FPM (182.9) face velocity without loss of filter efficiency and holding capacity. Filter media shall be layers of cleanable wire maze. Filter frame shall be constructed of galvanized steel.

3.5 Bag Filters

These filters shall be fine fiber, all glass media with spun backing to keep glass fibers from eroding downstream. Stitching method shall permit bag to retain pleat shape without the use of wire basket support. Bag filters to be furnished with pre-filter to extend life of bag filter. Manufacturer shall supply side access filter rack capable of holding bag filters and 2 in. (50 mm) pre-filters.

Bag Filters are to be provided of scheduled efficiency. Efficiency of filter to be determined by ASHRAE Standard 52-76. Filters shall be rated UL Class 2.

4. DAMPERS, MIXING BOXES AND PLENUMS

4.1 Outside Air/Return Air Dampers

Outside air/return air dampers shall be provided to modulate the volume of outside and return air. Dampers shall be of airfoil design and shall be either parallel or opposed blade type with metal compressible jamb seals and extruded vinyl blade edge seals on all blades. Blades shall rotate on stainless steel sleeve bearings. Maximum damper blade length shall be 60 in. (1500 mm). Leakage rate shall not exceed 5 CFM/ft² (0.79 m³/h·m²) at 1 in. wg (25.4 mm Aq.) and 9 CFM/ft² (1.42 m³/h·m²) at 4 in. wg (101.6 mm Aq.).

5. COMMISSIONING & TESTING

The unit shall be commissioned and tested as per the Manufacturer's recommendations. Drives shall be adjusted to provide the required air flow rate and valves shall be adjusted for the proper water flows, etc. This Contractor shall be required to carry out tests, on forms to be supplied later by the Consultants, and obtain the Consultant's approval. Supplier's representative to be present during commissioning and testing to certify that units are commissioned as per manufacturer's recommendations.

AIR VENT

Devices for air venting shall be provided at all highpoints in the pipe work. They shall be installed in the highest points of the sections which they are intended to vent.

Air bottles shall be made from 50mm size tube, each approximately 230 mm long, fitted with a cap and 8 mm size air cock; they shall be fitted with a cap and 8mm size cock; they shall be fitted to equal tees or have 50 mm size connections if the main is 50 mm size or above. Where an air bottle is fixed out of reach an 8 mm size extension tube shall be run from the cap to within 1.5 m of the floor, termination with an 8 mm size needle seated key operated air cock.

Automatic air vent shall be used where indicated. They shall have gunmetal or brass bodies, non-ferrous or stainless steel floats and guides, and non-corrodible valves and seats. Each automatic air vent shall be controlled by a lock-shield valve, air release pipe shall be run to discharge at the nearest visible point.

Air venting devices and air release pipes installed in exposed positions shall be insulated to prevent water freezing.

AUTOMATIC CONTROLS

The system automatic controls shall be selected with ranges and differentials suitable to give the required conditions of temperature and humidity as specified elsewhere for summer cooling / winter heating operation.

1. ELECTRIC / ELECTRONIC CONTROL SYSTEMS AIR HANDLING UNITS

The single zone airhandling unit shall have the following control system.

The temperature of the conditioned space during summer and winter shall be controlled by and electric low voltage proportional (dual input) temperature controller range 0-45 °C, adjustable differential 1-5 °C, to be installed on wall controlling the operation of modulating 2 way/3 way motorized valve installed in the chilled return piping from the coil. A limit duct insertion type dry bulb temperature sensor shall be installed in the supply air duct to limit the supply air temperature by acting as the 2nd input of the temperature controller.

2. FAN COIL UNITS

Coiling suspended fan coil units shall each have a fan switch and line voltage thermostat tube installed at 5'-0" level on wall. The manual fan switch would be 4-position 3-speed to control the fan motor operation. In "off" position, the switch shall cut off electric supply to the fan motor and automatic controls. The thermostat range 15' – 35' C, calibrated scale and differential 1.5'C, will operate a 3-way motorized valve with 5/8" OD male flare connections installed in water return piping. The valve shall be suitable for quiet operation, forged brass body, manual opener, working pressure upto 125 psig and quiet operation upto 10 psig pressure differentials. The pressure drop through the valve to be not over 10 ft. wg. With specified flow.

3. FIRE PROTECTION

One insertion type, line voltage, temperature limit controller set 60°C with manual reset shall be mounted at air handling unit outlet to stop the unit fan motor in case of temperature rise above the set point. The manual reset push button should be located in the front cover.

CLEANING, TESTING, BALANCING & TEST DATA

1. GENERAL

- (a) The entire testing balancing and adjusting process to be thoroughly organized & planned. All activities, including the organization, procurement of required test instrumentation and the actual system should be scheduled as soon as practical after the installation has been completed.
- (b) The contractor shall appoint an independent agency specialized in the testing & balancing of HVAC systems and their appointment must be subjected to consultant's approval.
- (c) Testing and balancing shall be performed in accordance with NEBB (National Environmental Balancing Bureau) USA, code of practices and all final reports shall be signed and certified by the agency appointed to perform such works.
- (d) The TBA agency must carryout the preparatory works which shall include the planning and scheduling of all TBA procedures, collecting the necessary data, reviewing the data collected, studying the system to be balanced, recording the published data on the test report forms, and finally, making preliminary field checks of the HVAC equipment and systems.

2. CLEANING & ADJUSTING

Pipe shall be cleaned free of scaled and thoroughly flushed of all foreign matter. Equipment shall be wiped clean, with all traces of oil, dust or paint spots removed. Temporary filters shall be provided for all fans that are operated during construction, and after all construction dirt has been removed from the building, new filters will be installed.

Bearings shall be properly lubricated with oil or grease as per recommendations of the manufacturer. Belts shall be tightened to proper tension.

3. TESTING

3.1 Duct Work

Ducts, plenums and casings shall be smoke tested and make substantially air tight at static pressure indicated for the system before covering with insulation or concealing in the masonry.

4. BALANCING

- (a) Duct system shall be balanced to produce air quantities within 5% of that indicated.

5. PERFORMANCE TESTS

After cleaning, balancing, and testing operations have been completed, as herein before specified, the system shall be tested as a whole to see that all items perform as an integral part of the system, and that temperature and conditions are evenly controlled throughout the building. Corrections and adjustments shall be made as necessary to produce the conditions indicated, at no additional cost to the Owner.

6. TEST DATA

6.1 General

The Contractor shall provide the Consultant with typewritten schedules of readings taken during the balancing and testing operation for the following items.

7. AIR BALANCE

(a) Fans

Size, type, speed in revolutions per minute, static pressure in inches of water, air quantity in

cubic feet per minute, and motor load in amperes and voltage.

(b) Coils

Size, face velocity in feet per minute, air-condition on-and-off Uni. Wet-bulb and dry-bulb temperature in °F., water temperature drop through cooling coil, temperatures entering coil in °F.

(c) Ducts

Size, velocity in feet per minute, and air quantity in cubic feet per minute.

(d) Air Outlets & Inlets

Size, velocity in feet per minute, and air quantity in cubic feet per minute.

8. CONTROL SETTING

The actual on site setting of all automatic controls including thermostats, safety controls, minimum damper settings, fan safety thermostats, pressure controls, temperature and humidity controls and other similar items shall be provided in the form of a tabulated list indicating type of control, location, setting and function.

9. OTHER EQUIPMENT

The contractor shall also provide written data on the performance of any other equipment; in the form and manner and giving all information required by the Consultant/Engineer. The Contractor shall also submit a certificate alongwith all test reports submitted, certifying that all test have been carried out by component engineers, and that all data submitted has been verified and found to be correct.

WATER TREATMENT SYSTEM

1. WATER TREATMENT EQUIPMENT (HVAC SYSTEM)

The Contractor shall furnish a complete water treatment system for the plant as generally shown on the drawings. It is the intent of this specification to ensure that all required equipment, operating instructions, test kits and other required apparatus are supplied to the owner.

The water treatment system shall cover the following sub systems.

1.1 Chilled water system

The chilled water system shall be treated by the addition of chemicals through "one shot" feeders. Feeders shall be of cast iron construction, complete with valves, funnel, drain line and other required fittings. Feeder volume shall be at least one gallon. Feeder shall be as manufactured as specified elsewhere in these documents.

The cooling water system shall be treated by the addition of chemicals through packaged chemical dosing sets (three numbers), one for each of the two biocides to be used in the cooling towers and one for the corrosion inhibiting treatment. Additionally, a control system for the biocides to be automatically alternatively dosed at periods which can be varied from 3 days to 4 weeks, shall be provided. This control system shall feature two independent control units mounted inside die-cast aluminium alloy casing and shall be complete with 100 litres, high density, polyethylene tank, variable delivery feed pumps suitable for corrosive liquids and driver motor and controls. The control system for biocides shall consist of, in addition to the packaged chemical dosing sets, an automatic dosing control suitable for alternately operating the pump sets for each biocide at predetermined intervals for a predetermined duration.

A total dissolved solids (TDS) control system shall be provided for continuously monitoring and correcting water quality by conductivity measurement. The system shall consist of a solid state control unit, indicator lamps, conductivity cell, weather proof case, 19 mm solenoid valve and other necessary components to complete the installation. The unit shall be temperature compensated and all necessary electrical wiring and connections for this unit shall be a part of this contract.

2. CHEMICALS

Chemicals to be provided shall be sufficient for one year.

- a) Scale/Corrosion inhibitor for open cooling water system, similar to Drawgard 308 of Drew Ameroid. Inhibitor must not contain any heavy metals and shall not require acid feeding for PH control.
- b) Cooling water biocides of two types with different chemical structures to prevent immunization by bacteria, similar to Biosperse 250 and Biosperse 280 of Drew Ameroid. Oxidization type biocides will not be acceptable.
- c) Corrosion inhibitor for chilled water system, similar to Drewgard 315 of Drew Ameroid. Chromate based inhibitor will not be acceptable.

The Supplier shall furnish complete test kits with one year's supply of reagents for the testing of water. The test kits shall be suitable for carrying out all necessary tests and be complete with instructions and apparatus must include a portable TDS measurement metre similar to Houseman HH-24.

The Supplier shall be responsible for obtaining a sample of the available water and getting it chemically analysed to calculate the chemical requirements for 8 hours daily operation for two years, which shall be submitted to the Project Manager for quantity verification. He shall furnish complete details of the chemicals and equipment's offered by him.

Locally made locally blended and locally packed chemicals will not be accepted.

All Chemicals supplied shall be of one manufacturer and detailed calculation of chemicals quantities and literature shall be provided.

INSULATION

1. DUCT THERMAL INSULATION

No insulation shall be applied to any duct work, or to any surface, until all foreign matter has been removed from the surfaces to be insulated. All insulation shall be applied in a manner consistent with good practice and methods.

Insulation shall be continuous through floors, walls, partitions, etc., except when otherwise indicated or specified. Where space will not permit application of insulation in wall or slab chase, the chase shall be packed full of 85% magnesia mineral wool, or Fiberglass and protected with cover plates, as approved by the Project Manager.

Ducts shall be insulated as specified in the schedule of equipment and materials.

The thermal conductivity at 24° C of fiberglass insulation shall not be over 0.039 Btu.inch./sq.ft.°F.hour.

For cold air ducts, fiberglass insulation shall have vapour barrier of aluminum foil with internal Fiberglass yarn reinforcement at maximum 25 mm centers, fixed with approved quality adhesive. Care will be exercised that vapour barrier is not damaged / pierced during installation, and any damage will be repaired with the same quality of vapour barrier.

The insulation shall be firmly fixed on the ducting / plenums with approved quality adhesive compound recommended by the insulation manufacturer. Adhesive to be approved by Project Manager. The adhesive shall cover at least 25% duct area on the sides and top and 50% area on the bottom. All circumferential and longitudinal joints shall be lapped at least 50 mm and fully sealed with adhesives. Where rectangular ducts are 600 mm in width or greater the insulation shall be further mechanically secured to the ducts, and at least 25 mm wide metal bands shall be applied at the corners so that the mechanical fastener does not pierce the insulation and vapour barrier.

The insulation shall be applied to the full length of the ducts, including portions where internal sound absorber liners etc. are fixed.

All access doors and removable panels shall be insulated and jacketed separately. The insulation jacket ends on the duct and door or panel shall be sealed with 50 mm wide PVC vapour seal self-adhesive type tape to prevent damage to the insulation due to use and servicing.

All cold air ducts in the conditioned space shall be insulated with 25mm thick 24Kg/m³ density fiberglass insulation vapour barrier sealed as specified above.

Exposed cold air ducts in unconditioned spaces shall be insulated with 50 mm thick, 32 kg density, Fiberglass insulation vapour sealed as specified above with.

External and weather exposed insulated ducting shall be insulated as specified and then protected with a jacket of 20 kg roofing felt, all joints sealed with hot bitumen PBS PB4 or approved equal. The jacket shall be further mechanically secured to the duct with 6 mm wide soft aluminum bands, generally spaced at 450 mm. Indigenous coarse cloth, canvas roofing felt and asphalt impregnated Kraft paper of approved quality are to be used.

Insulation shall be of manufacturers specified elsewhere in these documents. Insulating material shall be non combustible as defined in the NFPA standard 220.

2. ACOUSTIC INSULATION

Low velocity supply air ducts shall be provided with acoustic insulation for a distance of 15 linear feet from the fan discharge. Duct work sizes shown on the drawings are net clear sizes and wherever acoustic insulation is to be applied internally to the duct work, the Contractor shall suitably increase the duct sizes.

Acoustic insulation shall consist of semi-rigid bonded board of glass fibre, coated with black pigmented fire resistant coating on the side facing the air stream. The coating shall resist erosion up to 5000 Fpm. air velocities.

The insulation shall have a flame spread less than 25 per ASTM E 84-75. It shall have the following sound absorption characteristics per ASTM C 423-66.

	Octave Band Centre Frequency Hz.						
	125	250	500	1000	2000	4000	NRC
Thickness	Sound Absorption Coefficients						
1"	.13	.51	.46	.65	.74	.95	.60
2"	.25	.73	.94	1.03	1.02	1.09	.93

Application shall be per "Duct Liner Application Standard" published by the Sheet Metal and Airconditioning Contractors National Association USA (SMACNA). All portions of duct designated to receive duct liner shall be completely covered with Duct Liner Boards. Transverse joints shall be neatly butted and there shall be no interruptions or gaps. Board shall be cut to assure tight overlapped corner joints. The coated surface shall face the air stream. The duct liner shall be adhered to the sheet metal duct with 100% coverage of adhesive. All exposed leading edges and transverse joints shall also be coated with adhesive. In addition, mechanical fasteners shall be used to secure the duct liner board.

Adhesive shall be specially formulated for this specific application and the Contractor shall ensure the prior approval of the adhesive by the Project Manager.

Fibreglass sound absorbing liner shall be of manufacturers specified elsewhere in these documents.

The tenderer shall give complete technical details and manufacturer's technical bulletins for the acoustic insulation offered.

3. PIPE INSULATION

All insulating materials required for piping shall be furnished and installed under this Contract.

The execution of the work shall be by qualified insulation technicians, in strict accordance with the best practice of the trade and the intent of this specification.

(a) The schedule of pipe insulation is tabulated here below:-

Service	Material	Thickness	Density
Chilled Water/ Hot Water (2" & smaller)	Fiberglass (Dual temp.)	1 inch.	64 Kg/m ³
Chilled Water/ Hot water (over 2")	Fiberglass (Dual temp.)	1-1/2 inch.	64 Kg/m ³
Steam and Condensate Return	Fiberglass (Dual temp.)	2 inch.	80 Kg/m ³
Condensate Drain	Fiberglass (Dual temp.)	1 inch.	64 Kg/m ³
Refrigerant Copper	Closed Cell Rubber Foam.	1 inch.	

(b) The insulating material thickness used for straight pipe, fittings and valves shall be insulated by applying mineral wool cement and finishing with cement. Over the cement a cover of 2.44 kg/m² canvas shall be applied with approved adhesive. This adhesive shall also be used (with colour tint, where so directed) to thoroughly saturate and coat the canvas.

(c) Insulation on chilled pipes shall be protected by saddles from hangers, guides and rollers. Hangers shall not pierce insulation. Where Fibreglass insulation is used on piping 50 mm and larger, a half section of Kayla or cork pipe covering of equal thickness shall be used at metal shields.

- (d) Piping which is exposed to weather or called to be weather proof, shall be covered, in addition to insulation and finishes specified above, with 2.2 kg/m² roofing felt, lapped 75 mm on all joints, using adhesives specified above, and soft aluminium bands 300 mm apart and then clad with 0.5 mm galvanized metal sheet.
- (e) All vapour barriers shall be completely sealed against moisture penetration.

For chilled water piping, Fibreglass insulation shall have a factory applied Kraft reinforced foil vapour barrier and covering jacket. The jacket permeance shall not exceed 0.5 perm/cm. (ASTM E 96 Proc-A). Insulation and jacket shall have a flame spread of 25 or less per ASTM E 84-80. The thermal conductivity of insulation at a mean temp of 37.8 Deg. C shall not exceed 0.035 w/m-deg C.

Indigenous asphalt impregnated Kraft paper, canvas and roofing felt of approved quality are to be used. The tender shall confirm the type and thickness of insulation used and give details of vapour barrier, covering jacket, finishing and adhesive and supply manufacturer's technical bulletins.

4. EXPOSED DUCT

Exposed duct insulated with 1" thick aluminium foil fibreglass insulation & 2" thick magnesia lagging covered with 18G 3/4" mesh wire netting and an additional layer of 3/4" magnesia lagging applied. The surfaces shall be finished with 26 gauge G.I sheet Jacketing.

DUCTING

1. LOW VELOCITY LOW/MEDIUM PRESSURE SHEET METAL DUCTING

All sheet metal work for various air systems shall be furnished, installed, complete, connected, tested and adjusted.

The Contractor shall make shop drawings of all duct work and the same shall include details of all splitters, takeoffs, vanes, dampers, elbows and all other necessary fittings required for the proper operation of the air systems. Shop drawings and other details shall be submitted to the Consultant for approval before fabrication.

Exact dimensions and location of diffusers, registers, grilles and louvers shall be submitted to the Consultant for approval, otherwise and changes directed after installation shall be made by the Contractor without any additional cost to the Employer. For diffusers and registers adequate provision shall be made in the neck connections for installation of deflectors and dampers.

All duct opening, diffusers, register and grill necks / boxes must be tightly closed during construction to keep out rubbish.

All duct passing through walls shall have 20 gauge G.I. sheet sleeves extending 6mm beyond the finished face of the wall on both sides. The sleeves shall be of sufficient size to cover duct insulation or any other duct covering and allow at least 90mm clearance in the sleeve for free movement of the finished ducting. The clearance shall be filled with fiberglass pads or other approved material at firewalls and similar locations. The Contractor shall be responsible for supplying, location and setting of all necessary duct sleeves.

All sheet metal duct work shall be fabricated from commercial quality prime finish galvanizes steel sheet. The specifications for USA and Canadian sources shall be base steel sheet according to 525-64T, 1.25 oz./sq.ft . and for all other sources base steel sheets cold rolled B.S. 1449: Part 1B:1962 and zinc coating according to B.S. 2989:1958 Class D, 1.25 oz/sq.ft The zinc coating should be applied uniformly by continuous hot dip method to both sides of the base metal so that the sheet metal can be drawn, formed, lock-seamed and spun without danger of flaking or peeling off the zinc coating.

All uninsulated duct shall be cross broken. Insulated duct not to be cross broken.

All ducting shall be substantially built with approved joints and seams shall be made smooth on the inside and neat on the outside. The duct joints shall be made as air tight as possible. The laps shall be made in the direction of air flow and no flanges shall project inside the ducting.

Ducts, the width of the greater dimension of which exceeds 30 inch shall be constructed of not more than four feet sections. Ducts, the width of the greater dimension of which is 30" or less shall be constructed of the more than eight feet sections.

All elbows shall preferably be full radius type. If space does not permit, square elbows may be used with double thickness shop fabricated turning vanes riveted with the ducting. Due to space limitation curved elbows with less than a full radius bend may also be used provided single thickness turning vanes are installed in the elbow. Full radius elbows of widths 40"-60" shall have one and over 60" shall have tow single thickness turning vanes. Minimum throat radius of any curved or square elbow shall be 3 inches.

Wherever necessary in duct work, casing or sheet metal partitions, suitable access door and frames shall be provided to permit inspection, operation and maintenance of valves, controls, fire dampers, filters, bearings, traps or other apparatus concealed behind the sheet metal work. Access door shall be provided at distance not exceeding 23m for duct cleaning. All such doors shall be of double construction, of not less than 20 gauge G.I. Sheet metal and shall have sponge rubber gasket around the entire perimeter to make the joint airtight. They shall be hung on heavy flat hinges and shall be secured in the closed position by means of wing type catches. In no case shall access to any of the items of equipment requiring inspection, adjustment or servicing require the removal of nuts, bolts, screws, wedges or any other screwed or loose device.

The supply and return air duct connection with the fans and equipment shall be made through heavy duty air tight pre-fabricated flexible duct connector to prevent transmission of vibrations. The flexible duct connector will have 75mm 24g G.I. Sheet, 150mm of fabric and 75mm 24g G.I. Sheet. The fabric shall be fixed with G.I. sheet with double-lock grip. The fabric shall be non-combustible heavy glass fabric double coated with fire retardant neoprene to become fully water proof and air tight of approx. 30oz weight sq.yd. The flexible connector shall be Duro-Dyne Supper Metal Fab or approved equal.

The duct shall be adequately supported from hangers firmly fixed and generally suspended from the building structure with the help of concrete inserts, rawl bolts or shooting bolts. The hangers and supports shall not pierce the insulation, which shall be suitably protected and reinforced, at that location. The bottom support shall be 30x6mm M.S. flat or 25x3mm angle for duct upto 12" which, 30x3mm angel upto 30" width, 40x3mm angle upto 72" width and 50x5mm angle upto 96" width. Hangers shall be spaced on average 3 meter centers with a hanger no further than 300mm on each side of any changes of direction. Ducting passing through building expansion joints shall be supported on either side of joint. The hangers for horizontal duct shall be 9mm round rods for duct upto 30" width, 12mm round rods or 40x3mm M.S. flat upto 72" width and 40x5mm M.S. flat upto 96" width. The vertical duct shall be supported at each floor with MS flat straps riveted with the duct. Perforated band or wire shall not be used in any case for supporting the ducts.

The low pressure ducting with static pressure upto 50mm wg and velocities upto 10mps, shall be fabricated according to the following schedule:

Rectangular Ducting

To 8"	larger	dimension	26 gauge (all four sides)
9"-27"	larger	dimension	24 " "
28"-51"	"	22	" "
52"-81"	"	20	" "
Above 81"	"	18	" "

The ducts shall be fabricated with following type of joints or as approved:

(a) Longitudinal

Pittsburgh lock, double seam, or grooved seam.

(b) Circumferential (all four sides):

Duct larger dimension

To 23"	Drive slip
24" – 42"	1" high pocket lock or standing seam
24" – 42"	1 ½ " high pocket lock or standing seam.
24" – 42"	1 ½ " high reinforced pocket lock or standing seam.

The bracing for ducting shall be as follows:

Duct larger dimension	Size of bracing MS angle
To 23"	None
24" – 30"	Joints 4' centers without bracing or joints at 8' centers with 25x25x3mm bracing between joints.
31" – 42"	25x25x3mm bracing @ 4ft centers
	43" – 72" 40x40x3mm " @ 4 "
	73" – 84" 40x40x3mm " @ 2 "
	85" – 96" 40x40x5mm " @ 2 "

The 2' centers bracing would be located at joints and between joints.

The bracing shall be carried around all four sides, bracing angle frame welded at 4 corners and riveted with the duct at maximum 150mm centers.

Special joints, bracing and hangers as specified by the Consultant shall be used for duct with larger dimension over 96".

The medium pressure ducting with static pressure upto 150mm wg and velocities upto 15mps, shall be fabricated according to the following schedule:

Rectangular Ducting

To 18"	larger	dimension	24 gauge (all four sides)
19"-18"	larger	dimension	22 " "
46"-69"	"	"	20 " "
Above 69"	"	"	18 " "

The ducts shall be fabricated with following type of joints or as approved:

(a) Longitudinal

Pittsburgh lock, double seam, or grooved seam.

(b) Circumferential (all four sides)

Duct larger dimension

To 18"	1" high pocket lock, standing seam or bar slip.
19" – 36"	1 ½ " high pocket lock or standing seam.
37" – 48"	Reinforced standing seam with 40x40x3mm angle or 32x32x3mm companion angle flanged joint.
49" – 60"	40x40x3mm companion angle flanged joint.
61" – 84"	40x40x3mm companion angle flanged joint.

The companion angle flanged joints shall have neoprene gasket to make the joint air tight

The bracing for ducting shall be as follows:

Duct larger dimension	Size of bracing MS angle
To 12"	None
13" – 24"	25x25x3mm bracing between joints
25" – 42"	32x32x3mm bracing @ 2ft centers
37" – 48"	40x40x3mm " @ 2 "
49" – 60"	50x50x3mm " @ 2 "
61" – 84"	75x75x5mm " @ 2 "

The 2' centers bracing would be located at joints and between joints.

The bracing shall be carried around all four sides, bracing angle frame welded at 4 corners and riveted with the duct at maximum 150mm centers.

Special joints, bracing and hangers as specified by the Consultant shall be used for duct with larger dimension over 84".

The ducting and air dampers shall be furnished to comply with these specifications and latest edition of SMACNA Duct Construction Standards. Where there is a conflict between the two, these specifications will prevail.

ELECTRIC CONTROL BOARD

1. GENERAL

The machine control center shall be located in the plant room. It shall floor mounted designed for standing operation, each place of equipment on the panel shall be identified by a nameplate. Nameplate may be plastic or metal and attached to the surface of the panel or integral with it. Painting of lettering directly on the panel shall not be permitted. Control instruments, wiring and terminals shall be within panel, except that switches, pilot lights, push buttons and temperature indicator shall be mounted on the panel front. The front panel shall be hinged for front access.

2. CONSTRUCTION

The control center shall be constructed 90 inch and approximately 12-18 inch deep vertical section shall consist of flagged 14 gauge sheet steel. Side top back and full floor plates all rigidly joined by cross members and angle iron brackets.

Two removable floor channels 1 ½ inches by 3 inches shall be provided to support and mount the entire control center.

3. UNIT COMPARTMENTS

Provide each compartment with an individual front door. Starters and feeder unit doors shall be interlocked mechanically with the unit disconnect device to prevent unintentional opening of the door when the starter unit is energized. Means shall be provided for releasing the interlock if intentional access to the interior is desired, while starter unit are energized. Provide padlocking arrangement to permit the disconnection device to be locked in the "ON" or "OFF" position with the door in the open or closed position. Provision shall be made so that the overload relays may be reset from the outside of the enclosure.

4. BUS

Power shall be distributed horizontally within the control center by the three phase copper bus, silver plated, rated for the required Amps continuous current and braced for 25,000 ampere RMS asymmetrical short circuit current. The bus shall be effectively isolated from all wiring through and other working area. Front access shall be provide for inspection and maintenance. Power within vertical section shall be distribution by vertical copper bus base silver plated.

Provide copper ground bus having not less than 200 amps capacity in the base of the control center permanently grounding the structure. Provide lugs as required for ground wire attachment.]

5. INCOMING & OUTGOING CABLE TERMINATION

Provide a 12 inches or of wiring space just above or below the main bus of incoming cable. Provide space for outgoing cable through bottom of all standard vertical sections of the MCC.

6. MAIN PROTECTIVE DEVICE

The incoming line protection device unless otherwise specified shall be circuit breaker of the frame size and ampere rating required for the power supply to the plant.

7. MANUAL MOTOR STARTERS

All starters for single motor shall be magnetic direct-on-line type with two adjustable overload cutouts start/stop/reset push button. Where electric interlocking is required the starters should be automatic magnetic type with hand/ off/auto switch and at least two auxiliary contacts for electric or electronic interlocking current.

8. MAGNETIC MOTOR STARTERS

All three phase motor starters up to 10 HP shall be automatic magnetic -on-line type with hand/ off/auto switch three adjustable over load cutouts low voltage cutout, single phasing proverter, stop-reset push button and at least two contacts for electric interlocking current.

The motor 15 Hp and above shall have star delta type reduced voltage starters, generally manually operated unless otherwise specified to suit any automatic control of the equipment. The automatic starter shall have hand/ off/ auto switch. The manual starter shall have push button. All starters shall have three adjustable over load cutouts, low voltage cutout, single phasing protection, stop- reset push button, at least two auxiliary contact for electric or electronic interlocking current. All starters control circuit and magnetic coils to be suitable for 220 volt, 1 phase A.C. for motors requiring electric interlocking or remote control or sequence starting control or any other such feature, starters should have necessary auxiliary contact providing the desired control arrangement. A separate set of terminals is required for each control circuit. All motors and starters provided under this contract should be of one manufacturer except for the equipment where special motors and starters are provided as standard components.

9. UNIT NAMEPLATE

Each unit shall be identified by a ½ inch by 4 inch engraved nameplate.

10. MOTOR CONTROLS

Furnish and install all starters, over load heaters, as well as fuses unless specifically noted otherwise on the drawings. The selection of the over load heaters shall element types, unless specifically noted otherwise. They shall be properly coordinated and in general sized according to fuses manufacturer's recommendation for the loads served.

11. DISCONNECT SWITCHES

The disconnect switch shall be operable by hand from outside the enclosure and shall be so interlocked with the door or doors that it must be returned to the Off position before the door can be opened.

12. MOULDED CASE CIRCUIT BREAKER

The circuit breaker shall conform to the B.S. 4750 & IEC 157-1. It shall be constructed from high strength resin bonded thermostat providing the necessary combination of mechanical and electrical qualities. High pressure fixed and moving contacts shall be of silver alloy. The arc extinction is to be achieved by de-ionizing arc chute. Reception capacity shall be 25 KA, symmetrical at 400 volts.

The breaker shall be of thermal / magnetic type with a quick make-quick break trip free mechanism which shall prevent the breaker from closed and held-in against overload and held-in against overload and short circuit.

Breaker in rating more than 125 shall have adjustable magnetic and fixed thermal tripping. Breakers above 400 Amps shall have adjustable magnetic and thermal tripping elements.

Breaker in rating more than 400 shall be in draw out patterns in a self contained assembly making the breaker capable of being separated from supply, load and auxiliary connection.

The circuit breaker shall be provided with, if required, shunt trip, under voltage release and auxiliary contacts in specified combination.

The breaker shall be dolly operated with indication of 3 position mechanism ON-OFF-TRIPPED. To reset the breaker after automatically trip under fault condition, the dolly must be moved through the off position.

13. SELECTOR SWITCHES, PILOT LAMPS, RELAYS, ETC

In general where motor are to be automatically controlled a "HAND OFF-AUTO" selector switch shall be provided and mounted in the enclosure cover. Provide motor that are to be started manually with "START-STOP" button mounted in the enclosure cover.

For all motor installed in the plant room pilot lights, for ON-OFF-OVERLOAD status indication shall be provided on this panel.

Necessary relays etc. for interlocking starters, LEAD-LAG switch etc. shall also be provided.

The overload relays shall be of the soldered ratchet type.

Starters used on 400 volt circuits shall have a 220 volt step-down control transformer included in the enclosure of 530 volt amperes.

14. MACHINE CONTROL CENTER (MCC) CONFIGURATION

The machine central centre sieves detail about the configuration of the MCC, status the component to be installed in each MCC and shall be used in conjunction with the specification for the electrical works given here in.

ELECTRIC WIRING

The contractor will be responsible for complete electric wiring and earthing of the plant, equipment and controls. The Employer shall only provide 3 phase and neutral, 4 wire supply point (s) with two earthing points, and 1 phase neutral and earth 3 wire electric supply point (s) at locations shown in the drawing and detailed elsewhere in the documents.

The electric wiring shall be carried out on conduit, sheet metal channel of G.I. piping, all wiring buried in the floor to be in G.I. Pipe. The wire sizes shall be selected for satisfactory operation at least 45 C ambient temperature. The wiring and earthing shall be carried out according to the requirements of any local code and Pakistan P.W.D. Schedule.

The terminal connection for motors, and where required for starters, shall be made in flexible conduit.

On each control board incoming supply shall have a disconnect switch fuses, three phase indication lights, incoming supply voltmeter with phase selector switch, 1 ammeter for each phase and each outgoing individual circuit shall have disconnect switch fuse, ammeter for motors above 5 HP, starter for each motor, each starter hand/off/stop switch or stop/start push buttons and on-off overload green-yellow-red indicator lights, the disconnect switch fuse shall have HRC time lag link type fuses according to BS 88: 1952 and ASTA-20 certified. Two sets of replacement HRC fuses shall be supplied as spare for each disconnect switch.

Single phasing preventer relay shall be provided for each 3 phase circuit for 1 HP and above rating.

The contractor shall supply and install necessary electric controls board, disconnect switch fuses, earthing etc., complete the work, it would be required, where possible, to mount all the disconnect switch fuses, starters, switches, relay and controls in one place room on one control board for ease of operation. Where single phasing preventer and similar other safety devices are not part of equipment control panels supplied by the equipment manufacturer the contractor shall include all such controls and devices in his control boards.

The controls boards shall be of design and construction to provide easy access to all internal components for servicing and replacement. The board to have indicator name plates for all components for servicing and replacement. The board to have indicator name plates for all items. Size sets of complete wiring diagrams to be supplied to the Employer and one set to be kept in a pocket in each board.

The control boards shall be as fabricated by AEG/Johnson Philips/PEL/Prem/Sun Beam/Siemens or approved equal. Wires and cables shall be as manufactured by Pakistan Cables Ltd., Pioneer Cables Ltd. or approved equal.

EXPANSION JOINTS AND FLEXIBLE CONNECTORS

1. Expansion joints shall be supplied which shall confirm to the following specifications:

- i) Expansion joints shall be suitable for water 35 to 250° F, designed for 125 PSI. Operating pressure, with traverse capacity to relieve all stresses due to expansion or contraction of pipe at its operating temperature using a base temperature of 80° F.
- ii) Slip tube joints shall be single or double slip, with base and shall be designed to carry the weight of the expansion tubes by the means of machined guides at both ends of the tubes. Each joint shall be designed for replacement or addition of packing while operating under full line pressure. The joints shall be threaded end upto 2" and flanged for larger sizes.
- iii) Pickles type joints shall be internally guided and shall be provided with threaded and upto 2", flanged ends for larger size. Gasket or other means of sealing will not be permitted. When double compensators are used, they shall be provided with bases.
- iv) Flexible connectors shall be constructed of rubber, terafluoroethylene resin, or corrosion resisting steel, bronze, monel or galvanized steel. The material used and the configuration shall be suitable for pressure, vacuum, temperature and circulation medium. The flexible section may leave threaded welding, soldering, flanged or sockets ends and shall be suitable for service intended. The flexible section may be reinforced with metal retaining rings, with built-in-reinforcement and restriction bolts or with wire braid cover suitable for service intended. Flanged assemblies shall be equipped limits bolts to restrict maximum travel to within limits standard with the manufacturer. Unless otherwise shown on the drawings, the length of the flexible connectors shall be as recommended by the manufacturer for the service intended. Internal sleeves or liner shall be provide when recommended by the manufacturer. Covers to protect the bellow will be provide where necessary or directed. Flexible connectors shall be designed for 125 Psig. service, 260° F.
- v) Flexible connectors and expansion joints shall be Tozen, Kingsun, Metraflex and Econosoto.

EXPANSION TANK

Expansion tank (s) open type as specified in the drawings, for the chilled water system shall be located as shown on the drawings.

The tank be completed with all necessary controls accessories and fittings for proper working and as shown in the drawings.

The expansion tank shall be of suitable size for the function to be performed and shall be set on suitable supports and provided with all necessary connections as shown in the drawings.

FAN COIL UNITS

1. GENERAL

1.1 Quality Assurance

Furnish Fan Coil Units of type, size and capacity as set-forth and called for in the equipment schedules. Units shall be constructed to comply with the requirements of material and workmanship according to the latest ASME Codes or equivalent. Units shall be tested before dispatch and ready for installation and their performance certified in accordance with ARI standard 430 or equivalent.

1.2 Components

The units shall be complete with insulated casings, water proof insulated drain pan(s), coil(s), fan(s), motor and starter, motor and fan drives, filters and all other items necessary for satisfactory operation.

1.3 Coordination

The Contractor shall verify and confirm that the dimensions of the units offered by him are suitable for installation in the space available and he shall be responsible for ensuring that the units are capable of being installed in the available space.

1.4 Delivery, Storage and Handling

Units shall be delivered factory assembled with protective crating and covering and their delivery coordinated in sufficient time to allow movement into building.

1.5 General Warranty

The special warranty specified in this Article shall not deprive the Owner of other rights the Owner may have under other provisions of the Contract Documents and shall be in addition to, and run concurrent with, other warranties made by the Contractor/Supplier under requirements of the Contract Documents.

1.6 Special Warranty

A written warranty, executed by the manufacturer and signed by the Contractor/Supplier, agreeing to replace components that fail in workmanship, within the specified warranty period, provided manufacturer's written instructions for installation, operation, and maintenance have been followed:

Warranty Period, Fans :-	Manufacturers standard, but not less than 5 years after date of Substantial Completion.
Warranty Period, Coils :-	Manufacturers standard, but not less than 10 years after date of Substantial Completion.
Warranty Period, All :-	Manufacturers standard, but not less than 2 years other components after date of Substantial Completion.

1.7 Extra Materials

Furnish extra materials described below that match products offered/installed, are packaged with protective covering for storage, and are identified with labels describing contents.

Filters :-	One set of filters(as specified) for each unit.
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2. COMPONENT FEATURES

2.1 Unit Casing

a) General Construction

Unit shall be constructed of a complete frame with removable panels. Removal of side panels must not affect the structural integrity of each module. All exterior wall panels shall be made of minimum 18 gauge G90 galvanized steel.

b) Base and Frame

The unit base and upper frame shall be hot dipped galvanized.

c) Wall Construction

Units shall be single wall constructed.

Units shall be factory insulated with insulation of minimum density $1\frac{1}{2}$ lb/ft³ (24 kg/m³) insulation. The insulation thickness and density is to be selected by the manufacturer to ensure that the following minimum criteria are met:-

Heat Transfer Coefficient:- 0.20 Btu/h·ft²·°F (1.15 W/m²·K)

Noise Attenuation Characteristics:- As per table below

Frequency (Hz)	63	125	250	500	1 k	2 k	4 k	8 k	Overall
SPL (DB)	11	11	15	25	26	27	27	27	<30

No condensation to occur on unit exterior when air around unit is at:- 100°F (37.78°C) and 65% RH

All connecting channels shall also be insulated to prevent sweating.

d) Drain Pan

Units shall have an insulated, double wall galvanized drain pan under cooling coil section(s) for drainage of condensate. Minimum insulation requirements for the drain pan are as detailed in the section on 'Wall Construction'. Drain connections are to be provided on both sides of the unit.

e) Paint

Units shall be finished with two coats of baked enamel/powder coating.

2.2 Fans

a) General

Fan(s) shall be rated in accordance with AMCA Standard 210. Fan(s) shall be directly connected and selected to produce the capacity required at the static pressure indicated.

b) Type

Fan(s) shall be of the fully enclosed centrifugal type, double width, double inlet, forward curved, Class I; Fan(s) shall be statically and dynamically balanced.

c) Housing

Fan housing shall be constructed of heavy gauge steel equipped with intake cones designed for smooth air flow.

Housed fan performance shall be certified as complying with ARI Standard 430-89.

d) Acoustic performance:-

Minimum acceptable fan/AHU acoustic performance shall be as indicated in table below:-

Frequency (Hz)	63	125	250	500	1 k	2 k	4 k	8 k	Overall
Fan Lw (dBA)	55	67	75	80	80	78	74	67	85
AHU Lw (dBA)	54	65	69	72	71	65	54	44	76
SPL* (dBA)	43	54	58	61	60	54	43	33	65

* Sound Pressure computed at 3.28 feet (1.0 m), in free field space

2.3 Coils

a) General

Coils shall be manufactured by the same company as the supplier of the air handling unit. Coils shall be designed with aluminum plate fins and copper tubes.

Fins shall have collars drawn, belled and firmly bonded to the tubes by means of mechanical expansion of the tubes. No soldering or tinning shall be used in the bonding process. Coils shall be mounted in the unit casing to be accessible for service and can be removed from the unit either through the side or top. Capacities, pressure drops and selection procedure shall be certified in accordance with ARI Standard 410.

b) Water Cooling Coils

Water Cooling Coils shall be supplied where scheduled and shall conform to the following minimum specifications:-

- Coils shall be designed to operate at 250 psig (17.5 bar) design working pressure and up to 300°F (148.9°C). Coils shall be tested with 325 psig (22.75 bar) compressed air underwater.
- Coil circuiting shall provide free draining and venting when installed, counter flow of air and water, with water velocities not to exceed 7FPS (128 m/min) and without exceeding the water pressure drops scheduled.
- All coils shall be enclosed in a coil section. Coil headers and U-bends shall not be exposed.
- All coils must have same end connections regardless of the number of rows deep.
- Coils shall have a supply header to ensure distribution of cold water to each tube of coil. Headers shall be either round copper or cast iron. Steel pipe headers are not acceptable.
- Tubes shall be ½ in. (12.7 mm) or 5/8 in. (15.875 mm) OD.

INSTRUMENTS

The contractor shall supply and install all necessary indicating thermometers, gauges etc., for easy checking of operation of the complete plant. Amongst others, the following instruments and measuring points shall be included but duplication of instruments and points is to be avoided. The selected scale range of instruments shall suit the anticipated operational range. The suggested ranges are 10-35, 0-50, 0-70, 0-100, PSI and 0-200F for thermometers and 30" Hg-108ar, 0-15 and 0-25 bar for pressure gauges.

Insertion type duct mounted 3" dia thermometers shall be provided in each supply, return and fresh air duct.

Wall mounted dial type or straight stem type thermometers shall be installed in the rooms as shown in the drawings.

Compound/ pressure gauge, at least 3" diameter with Bourdon tube element and internal mechanism with individual bearings to give best accuracy under fluctuating pressure and vibrations shall be provided to indicate the refrigerant and oil pressures.

Inclined scale manometers of 0-200 mm. w.g. scale range shall be installed across each air filter bank.

The instruments shall be Ashton/ Ashroft/ Negretti and Zambara/ Taylor/ Weksler manufacturer or approved equal.

The tenderer to give complete details of all the instruments offered by him.

MINI SPILT UNITS

1. GENERAL

The work includes the provision of all labour, materials, equipment's, accessories, services and tests necessary to complete and make ready for the operation as shown on the drawing and hereinafter specified. The installation shall be completed in a very respect, tested and approved to the satisfaction of the consultant and in accordance with the local laws governing these installations.

The installation will include, but not limited to the following:

Air-cooled decorative spilt units.
Complete control wiring.
Control thermostats.

All components will be new according to the specifications. No second-hand materials what so ever will be accepted. The contractor may be required to produce certified invoices.

2. EQUIPMENT

Each spilt unit shall consist of two parts assembled tested and ready for operation.

- (a) An outdoor condensing unit.
- (b) A decorative type fan coil unit.

The two parts shall be connected together with quick connection, pre-charged and insulated refrigerant piping.

2.1 Outdoor Unit

The outdoor condensing units shall be located as per drawings and shall contain sufficient refrigerant (R-22) for the complete system and shall be equipped with refrigerant line fittings. Brass service calves shall be located at the exterior of the unit.

The compressor shall be of the welded hermetic type rotary/reciprocating with internal vibration isolators and shall be located in an isolated compartment of the unit to reduce the noise level. The compressor shall be equipped with safety devices like crank case heater, thermal and current sensitive overload devices and low pressure cutout switch.

The condenser coil shall be constructed of aluminum fins mechanically bonded to copper tubing.

Condenser fan shall be direct driven propeller type and arranged for either horizontal or vertical discharge. Fan hub shall be designed to protect motor shaft, bearing and winding. Fan motor shall be factory lubricated and inherently protected. The whole units shall be housed in a weather proof cabinet.

2.2 Indoor Unit

The indoor units shall be exposed decorative type ceiling suspended / cassette / floor mounted according to the drawings and consultant approval.

The units shall be fabricated from galvanized steel sheet and shall be internally insulated. The cabinet shall be pre-painted with baked enamel paint and provided with adjustable plastic grills. The coil shall be made from copper tubing with mechanically boned aluminum fins. The fan shall be Centrifugal, direct driven, doubt inlet type with two impellers.

The impellers and scrolls shall be made in shock poof material t guarantee maximum stability during transport and installation. The impeller shall be having airfoil blades.

The motor shall be permanent spilt capacitor type single phase and shall be totally enclosed. The units shall be complete with remote control kit consisting mainly of three speeds and off switch and a thermostat.

3. REFRIGERANT PIPING

Suction and discharged refrigerant piping shall be pre-charged, installed and quick connect type. Insulation shall be of closed cell rubber foam with a minimum thickness of 19mm.

Piping penetrating walls shall pass through a Pvc sleeve and to be sealed for water proofing and the contractor should submit detailed working for the way proposed for consultant approval.

3.1 Finishing

All piping shall be insulated as mentioned before and additionally wrapped with canvas clothing and painted with a weather proof painting.

3.2 Return Air Filter

Return air filters shall be permanent, washable type of preferably from the same manufacturer.

PIPE INSULATION

All insulating materials required for piping shall be furnished and installed under this Contract. The execution of the work shall be by qualified insulation technicians, in strict accordance with the best practice of the trade and the intent of this specification.

(a) The schedule of pipe insulation is tabulated here below:-

Service	Material	Thickness	Density
Chilled Water/ Hot Water (2" & smaller)	Fibreglass (dual temp.)	1 inch	64 Kg/m ³
Chilled Water/ Hot water (over 2")	Fibreglass (dual temp.)	1-½ inch	64 Kg/m ³
Steam and Condensate Return	Fibreglass (dual temp.)	2 inch	80 Kg/m ³
Condensate Drain	Fibreglass (dual temp.)	1 inch	64 Kg/m ³

- (b) The insulating material thickness used for straight pipe, fittings and valves shall be insulated by applying mineral wool cement and finishing with cement. Over the cement a cover of 2.44 kg/m² canvas shall be applied with approved adhesive. This adhesive shall also be used (with colour tint, where so directed) to thoroughly saturate and coat the canvas.
- (c) Insulation on chilled pipes shall be protected by saddles from hangers, guides and rollers. Hangers shall not pierce insulation. Where Fibreglass insulation is used on piping 50 mm and larger, a half section of Kaylo or cork pipe covering of equal thickness shall be used at metal shields.
- (d) Piping which is exposed to weather, or called to be weather proof, shall be covered, in addition to insulation and finishes specified above, with 2.2 kg/m² roofing felt, lapped 75 mm on all joints, using adhesives specified above, and soft aluminium bands 300 mm apart and then clad with 0.5 mm galvanized metal sheet.
- (e) All vapour barriers shall be completely sealed against moisture penetration.

For chilled water piping, Fibreglass insulation shall have a factory applied Kraft reinforced foil vapour barrier and covering jacket. The jacket permeance shall not exceed 0.5 perm/cm. (ASTM E 96 Proc-A). Insulation and jacket shall have a flame spread of 25 or less per ASTM E 84-80. The thermal conductivity of insulation at a mean temp of 37.8 Deg. C shall not exceed 0.035 w/m-deg C.

Indigenous asphalt impregnated Kraft paper, canvas and roofing felt of approved quality are to be used. The tender shall confirm the type and thickness of insulation used and give details of vapour barrier, covering jacket, finishing and adhesive and supply manufacturer's technical bulletins.

PIPING

All black M.S. Piping 2" and above shall be arranged with welded joints, providing flanges where necessary for easy dismantling. In particular flanged joints shall be provided for equipment, valves, strainers, expansion joints and other specialties. The welding fitting shall be Tube-Turn or as approved.

All site welding shall be done by electric ARC welding process with all joints 45 deg bevel type. Pipe to be mill bevelled or bevelled at site by the contractor. All scale and oxide shall be removed with hammer, chisel or file, levels shall be smooth and clear before welding with tow pipe ends to be lined straight and concentric.

Both conductors ;and welding machine shall be brought to the work location and shall be taped and held together prevent induced currents in pipes, other metals and structural steel.

The earthing lead shall be connected to pipe with suitable clamp in a manner so that welding current shall not flow through pipe joints, pipe supports or structural steel.

The weld shall be thoroughly fused with base metal at all pints and the welds shall be of sound metal and free from slag or other defects.

All welders shall be fully qualified and approved; for the work. If required their test certificates shall be submitted to the consultants for approval before the welders are allowed to work.

When screwed joints are used for pipe size 1-1/2" dia and below the screw thread shall be cut clean and true. Screw joints made tight without caulking, red or white lead. Reducing fittings shall be used. All necessary unions shall be provided for easy dismantling.

All pipes shall be properly supported on clamps, hangers etc. of approved design. Supporters shall be designed; to permit, free expansion and contraction to minimize vibration. All hangers clamps, etc. for piping in the plant room inspection passages and vertical risers shall be provided ;with rubber-in-shear or equal anti-vibration supports ;with the building structure to prevent transmission of vibration to the building structure. No pipe shall be suspended from other pipes.

In general for horizontal piping supports and hunger rod size shall be as per following:

<u>Pipe Size</u>	<u>Max.Span ft.</u>	<u>Min.Rod Dia-meter</u>
Upto 1" dia	7"	3/8"
1-1/4" & 1-1/2" dia	9"	3/8"
2" dia	10"	3/8"
2-1/2" & 3" dia	12"	1/2"
4" & 5" dia	14"	1/2"

Additional Supports shall be provided for larger sized headers, valves, strainers, tees and other special fittings.

All vertical pipes shall be supported by heavy clamps resting ;on the building structure.

Hungers for insulated piping shall have broad contact areas for pipe size 2 inches or smaller and high density insulation sections for pipe size above 2 inches so as not damage insulation by load concentration. The hangers shall also support insulated pipe without piercing the insulation or the vapour barrier.

The piping hangers, to be supported from building structure, shall be supported from concerned inserts or properly sized expansion bolt of at least the diameter of the hanger rod, subject to safe carrying duly certified by the manufacturer and to consultant's approval.

All pipe work shall be so arranged and assembled so as to prevent undue strain or leak caused by expansion and construction. The riser branches shall be arranged to take up motion of risers and mains. The piping will be anchored at suitable locations to limit the expansion and construction. Expansion joints suitable for working pressure (minimum 100 psing) shall be of stainless steel bellows type, with external protection and internal sleeve and factory installed flanges.

All pipes passing through floors or walls shall have 20 gauge G.I. sleeves for the full depth of the floor construction or thickness of the wall and extending 15 mm beyond the finished face or structure. All

sleeves shall be of sufficient size to cover pipe insulation or any other pipe covering, and allow outlast 3 mm clearance in sleeve for free movement of piping. The contractor shall be responsible for supplying, location and setting of all necessary pipe sleeves.

The pipe shall be properly graded to secure easy circulation and prevent noise and water hammer. Maximum possible pitch shall be allowed to the points where vent, relief, drip and drain connection are provided. Capped dirt pockets shall be provided at all riser bottom, low point and other places where dirt and scale may accumulate. Generally the contractors should provide drain cocks at all low points and automatic vents at all high points.

At the time complete air conditioning plant is operated and tested and any of the coil etc. do not have rapid and noiseless circulation due to coils etc. do not have rapid and costless circulation due to trapped or air bound connections or any other reason of defective installation and workmanship, the contractor shall be responsible to make proper alteration in these defective connections and if these are concealed in the false ceiling, floors etc and the same has to be taken down or broken and refinished the contractor shall bear all expenses in this connection all elbow shall be long radius type except where space limitations necessitate use of short radius type.

The contractor shall provide stop valves, check valves, drain cocks, traps, automatic vents, manual vent, thermometers, pressure gauges, strainers and other specialties as are required for proper operation of the whole system. Generally, necessary valves etc. are shown in the drawings. All cast-iron body valves shall have renewable bronze seat rings, bronze seat rings, bronze spindles and to have self packing feature so that they can be packed while open and under pressure. The valves in the plant room which are more than 1.5m above the floor level shall be provided with chain-operated sheaves and chains. Valves 2-1/2" and above should be with flanges except for drain piping where screwed valves may be used with unions for easy dismantling. All valves for throttling services in pump discharge, water chiller outlet and cooling coil outlet connections and where specified on the drawings shall be of the globe type. The valves shall be design and construction to conform to the working pressures of the system, but for minimum 125 psig rating.

The contractor shall provide strainers where necessary to protect all equipment, automatic control valves, etc. where proper functioning would be affected by the dirt on the seat or by scoring of the seat. The strainer shall be provided in the inlet connection of each automatic control valve, pressure reducing valve, pump suction makeup water connection etc.

PUMPS

1. CENTRIFUGAL WATER PUMPS

Furnish centrifugal pumps of sizes, types and performance ratings as listed on the schedule.

The pumps shall be single stage, volute type, cast iron body, fully bronze or stainless steel fitted with bronze impeller of radial type and double curvature vanes, stainless steel shaft or shaft sleeve, properly lubricated bearings, readily accessible stuffing box with packing and mechanical seal cage, flanged suction and discharge connections, integral cast iron base plate for the pump and the motor with drain outlet for connection to the nearest drain point, flexible coupling between the motor and the pump shafts covered with approved guard, pump casing to be complete with drain and vent plugs and designed, tested and proven tight for a test pressure at least equal to 1-1/2 times the maximum working pressure.

The pumps shall be direct driven by a constant speed motor. The pump motor BHP has been given for each system for guidance, but it is intended that motor of higher BHP shall be provided if required to ensure that it is not overloaded under any possible operating conditions of the pump.

Each pump shall be guaranteed to circulate not less than the specified quantity of water against the specified circulating head, when operating continuously without overheating the motor or bearings. Pumps shall be quiet in operation, without producing noise audible anywhere in the building outside of the space in which the pumps are installed.

The pump impeller and motor should be so selected that these are not overloaded when only one pump is operating and increased water flow is to be handled due to reduced system head.

TOOLS & SPARES

All necessary special tools and instruments required for proper operation, servicing and maintenance of the complete installation should be supplied. Complete list of these shall be included in the tender.

Complete set of spare parts for all items required for two year's operation shall be included. In addition to other spare parts, the tenderer shall also include 5% of each size of supply and return air diffusers, registers and grills (minimum one of each size) 20% of air filters, one of each type of three-way valves, sensors, controllers and room thermostats. Tenderers shall give a list of all the spare parts offered by them. Recommendations of manufacturers of equipment for two year's spare parts requirements shall be included by the contractor. Giving only percentage to main item will not be acceptable.

Special Tools and Instruments for Maintenance

The following tools shall be included:

1.	Two speed electric hand drill suitable to bore 1/2" in steel, with set of high speed drilling bits containing atleast 13 bits.	1	No.
2.	Pipe wrench 14" china origin.	1	No.
3.	Pipe wrench 8" china origin.	1	No.
4.	Spanner (13 Pieces).....	1	Set.
5.	Cutter & plier diamond brand china origin.	2	each
6.	Hammer 1 Kg.	1	No.
7.	Hammer 2 Kg.	1	No.
8.	10-pieces screw driver set.	1	Set.
9.	3-pieces Philips screwdriver set.	1	Set.
10.	Electric Tester Philips.	1	Set.
11.	5-pieces files set for steel.	1	Set.
12.	Variable spanner 3 sizes set.	1	Set.
13.	Table vice.	1	No.
14.	Pipe cutter size upto 3" pipe.	1	No.
15.	Nose Plier.	2	Nos.
16.	Hand saw.	2	Nos.
17.	Flairing tool kit.	1	Set.
18.	Copper tube cutter for item No. 17.	1	Set.
19.	Cleaning blower.	1	No.
20.	Lobortary thermometers for water circuits and air duct work.Total	6	Nos.
21.	Accurate pressure gauges (+ 1/2% accuracy) for water circuits.	3	Nos.
22.	Air balancing meter to measure both air velocity and temperature.	1	No.

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|-----|--|---|------|
| 23. | Pilot- tube set suitable for maximum duct sizes shown in the drawings. | 1 | No. |
| 24. | Clamp-on meters for current with additional accessories for voltage and resistance measurement. | 2 | Nos. |

The above tools shall be mounted in wheeled wooden or steel box of suitable size.

VALVES AND ACCESSORIES

1. GENERAL

Supply, Installation of valves and other pipe work accessories as indicated on drawings, specified herein and as per instruction of Consultant.

2. VALVE DESCRIPTION

Unless otherwise specified, valves should be of the same nominal size as the size of the pipeline to which they are connected. All valves that incorporated packed glands should be capable of having glands packed when connected in line and subject to the working line pressure. All isolating valves shall provide tight shutoff in the close position.

All hand wheel valves shall rotate clockwise to close the valves. Check valves should be install in a plane only which is recommended by the manufacturer and approved by the Consultant.

Valves bonnets and covers should be easily removable and the gasket and glands should be readily renewable.

All gate and sluice valves shall incorporate guides in the body to ensure the correct position of valve discs at all times. The working parts of valves and cock should be bronze and the body casting should be bronze for valves and cocks up to 50 mm. connection and cast iron for valves and cock of 65 mm. diameter connection and above.

Gland rings and spindles should be of a good running fit and stuffing boxes should be fitted with neoprene 'O' ring seals. The exterior finish of all bronze valves bodies should be polished except otherwise specified.

Check valves up to and including 65 mm. diameter should be of 'Y' pattern swing type having regrindable bronze discs with the discs with the disc seat integral with the valve body. The disc and seat should be accessible via a screwed cap of regrinding without removal of the disc.

Isolating valves for all water piping should be full way type gate valves unless otherwise indicated and should be fitted in the following positions, whether shown on drawings or not:

- Inlet and outlet connections to pumps.
- Inlet and outlet connections to water strainers and filters.
- Inlet and outlet connections to tanks.
- Inlet and outlet connections to three Port Valves.
- By pass connection around valves and equipment.
- Branch connection from service mains.
- At top or base of the riser served from below or above.

3. ACCEPTABLE STANDARD FOR VALVES AND COCKS.

The following valves should be those used for all systems, unless otherwise specified.

- Gate valves incorporating sedges and disc shall comply with the following British Standard according to sizes.

Smaller than 50 mm	B.S. 5134
50 mm and larger	B.S. 5150

- Globes valves shall comply with following British Standards according to sizes.

Smaller than 50 mm	B.S. 5154
50 mm and larger	B.S. 5152

- Check valves shall comply with following British Standards according to sizes.

Smaller than 50 mm	B.S. 5154
50 mm and larger	B.S. 5153

- Butterfly valves shall comply with following British Standards according to sizes.

50 mm and larger

B.S. 5155

Disc valve shall comply with BS 5154 for sizes 50mm. and smaller. Ball valves shall comply with B.S. 5159 for all sizes specified.

Stopcocks shall comply with B.S. 1010 Parts 2 with polish copper alloy bodies.

Drains cocks for water services shall have bronze bodies and shall comply with B.S. 2879 type A. Ends shall be suitable for connecting to a flexible hose.

Ball float valve should be internally hydraulically balanced double seated pattern. The operating mechanism should be properly fixed to an arm of brass, which in turn shall be fixed to tinned copper float. The valve body shall be of bronze body. The valves faces shall be synthetic rubber. The hinge pin and bushes shall be copper alloy.

Regulating valves for all water services for size 50 mm. and smaller should be lock shield pattern disc type with parabolic shaped slotted disc and shall regulate the flow in proportion to the lift of disc. Regulating valves larger than 50mm. size shall be globe pattern valves.

Bib cock shall be male inlet, face of wall type chromium plated. Pressure relief valves shall be spring-loaded angle type, water pressure relief valve located in water line and constructed with semi-steel body, bronze trim.

4. STRAINERS

Strainer should be 'Y' pattern and cast iron body, working pressure should be equal to or greater than the maximum water pressure. The drain cock should be provided for cleaning purpose.

5. CAPS

Should be machined, gasketed and with straight threads or bolted type.

6. UNIONS AND FLANGES

Unions and Flange should be furnished and installed at each threaded or flanged connection to all equipment or valves. The faces of flange being connected should be alike in all cases. Union and flanges should be located so that pipe can be easily disconnected for removal of equipment, valve or tank.

SCHEDULES

SCHEDULE OF FAN COIL UNITS

FCU Tag No.	Qty.	Supply Air (CFM)	Fresh Air (CFM)	ESP (inch WG)	Electrical Power (KW)	Cooling (Air Side)		Cooling (Water Side)		
						Total Coil Load (MBH)	Entering DB/WB deg.F	EWT deg. F	LWT deg.F	Flow Rate USGPM
FCU2	4	800	120	0.15	0.5	25	80/67	44	54	5
FCU1	4	600	90	0.15	0.5	20	80/67	44	54	4

Notes:

Unit Type: Ceiling suspended, ducted type

Units Consist of three way Motorized Valves with Controller

Duct mounted Thermostat

2" thick washable; Aluminum air filters

Max Coil Face Velocity: 500 FPM

All Parameters are indicative only, actual parameters to be provided by supplier along with computerized selection for approval.

SCHEDULE OF EQUIPMENT

AIR COOLED CHILLER

1	Qty.	2 Nos.
2	Cooling Capacity (each)	150 Ton
3	Chilled Water Circuit	
	Inlet/Outlet Temp.	44 -54°F
	Water Flow (each)	360 USGPM
	Fouling Factor	0.0001(sqft.hr. °F/Btu)
	Pressure Drop (Max.)	15 Ft wg
4	Number of Compressor (Max.)	2 Nos.
5	Ambient Temp.	105 °F
6	Refrigerant	R-134a
7	Electric Source	
	For Power	400V-50HZ-3Phase
	For Control	220V-50HZ-3Phase
8	Total Electrical Power Consumption (each)	150 KW(Nominal)
9	Operating Weight	10 Ton
10	Spare Parts	As per Manufacturer's recommendation
11	Computer Selection Sheet	Computer selection with performance data should be submitted for approval.

SCHEDULE OF CENTRIFUGAL PUMPS

1	Tag No.	CHP-P	CHP-S
2	TYPE	END SUCTION SPLIT CASING, CENTRIFUGAL	END SUCTION SPLIT CASING, CENTRIFUGAL
3	QUANTITY	3 Nos.	3 Nos.
4	MAKE	KSB or Equivalent	KSB or Equivalent
5	MOTOR MAKE	SIEMENS	SIEMENS
6	SERVICE	Primary Chilled Water	Secondary Chilled Water
7	WATER FLOW RATE- (USGPM)	360	360
8	CIRCULATING HEAD, (FT)	60	100
9	MOTOR	TEFC, IP55	TEFC, IP55
	a) HP	15	20
	b) RPM	1450	1450
	c) Power Supply System	415 V/3- PH/50 HZ	415 V/3- PH/50 HZ
	d) Voltage rating	380/400V	380/400V
10	PRESSURE RATING, (PSI)	125	125
11	Accessories	Standard	Standard
12	Remarks	WITH MECHANICAL SEAL AND STAINLESS STEEL SHAFT	WITH MECHANICAL SEAL AND STAINLESS STEEL SHAFT

Note:

All Parameters are indicative only supplier should provide actual performance parameters along with computerized selection sheet for consultant's approval.

Unit shall comply with all applicable ASME/DN Standards as per specifications.

SCHEDULE OF VENTILATION FAN

1	Qty.	08 Nos.
2	Make	Greenheck, Pennbarry or Equivalent
3	Service	Exhaust Air
4	Type	Centrifugal, Cabinete Type
5	Air Flow	14000 CFM
6	Static Pressure	2.5" wg
7	Drive	Belt Driven
8	RPM	1500 Max.
9	Power Supply Rating	220 V/3-PH/50 HZ
10	Misc. Items	Fan Bearing, Weather Proof Construction with Filters/Planum

APPROVED MANUFACTURER LIST

LIST OF APPROVED MANUFACTURERS / SUPPLIERS

IMPORTANT NOTE:- Engineer has the right to select any material from the list of approved materials / suppliers.

Sr No.	Materials	Approved Manufacturers / Suppliers			Remarks
		Brand 1	Brand 2	Brand 3	
1	ARCHITECTURE WORKS				
A	CARPENTRY / WOOD WORKS				
1	Doors	BEST QUALITY TEAK WOOD, BEST QUALITY DOEDAR WOOD			Or other Equivalent approved by Engineer
2	UPVC Compstite Doors	ALFAPEN	AVT	FRAMZ	Or other Equivalent approved by Engineer
3	Ironmongery - Locks + Cylinder (ALL ACCESSORIES)	SWELL, UK	KHAFLI, ITALY	CORBIN	As per the approval of the Consultant.
B	METAL WORKS				
1	Aluminum Sections	Alcop	PAKISTAN CABLES	KURDSUN	Or other Equivalent approved by Engineer
2	Aluminum Locks, Aluminum Accessories	Dorma, Germany	Yale, UK, Cosma, Italy	-	Or other Equivalent approved by Engineer
3	Aluminum Cladding	Aluco-Bond	Alpolic	-	Or other Equivalent approved by Engineer
4	Shutters	LOCAL MAKE			-
C	GLASS				
1	Plain Glass	PILKINGTON	GUARDIAN	SAINT GOBAIN	Or other Equivalent approved by Engineer
2	Reflective Glass	PILKINGTON	GUARDIAN	SAINT GOBAIN	Or other Equivalent approved by Engineer
3	Protective Glass Series	PILKINGTON	GUARDIAN	SAINT GOBAIN	Or other Equivalent approved by Engineer
D	TILING AND CLADDING				
1	Flooring Tiles (Kitchen & Bathrooms)	SPAIN	U.A.E.	CHINESE	Or other Equivalent approved by Engineer
2	Porcelain Tiles (For General Flooring) Matt & Glazed	SPAIN	U.A.E.	THAILAND	Or other Equivalent approved by Engineer
3	MARBLE TILES	LOCAL MAKE			All Types, Sizes & Shades & Any Other Equivalent Aproved By Engineer
4	PAVEMENT TILES	ENVICRETE	-	-	Or other Equivalent approved by Engineer
5	GRANITE	BEST LOCALLY AVAILABLE			Or other Equivalent approved by Engineer
6	STONE CLADDING	BEST LOCALLY AVAILABLE			Or other Equivalent approved by Engineer
E	PAINTING				
1	Weather Shield	I.C.I Paints, Pakistan	Berger Paints (Pakistan)	GOBIS / JOTUN	Or other Equivalent approved by Engineer
2	Internal Paints- Matt Enamel	I.C.I Paints, Pakistan	Berger Paints (Pakistan)	GOBIS / JOTUN	Or other Equivalent approved by Engineer
3	Internal Paints- Emulsion	I.C.I Paints, Pakistan	Berger Paints (Pakistan)	GOBIS / JOTUN	Or other Equivalent approved by Engineer
4	Wood Paint	I.C.I Paints, Pakistan	Berger Paints (Pakistan)	GOBIS / JOTUN	Or other Equivalent approved by Engineer
5	SYNTHETIC ENAMEL PAINT	I.C.I Paints, Pakistan	Berger Paints (Pakistan)	GOBIS , PAKISTAN	Or other Equivalent approved by Engineer
6	FLOURESCENT PAINT	I.C.I Paints, Pakistan	Berger Paints (Pakistan)	GOBIS / JOTUN	Or other Equivalent approved by Engineer
7	EPOXY PAINT	I.C.I Paints, Pakistan	Berger Paints (Pakistan)	GOBIS , PAKISTAN	Or other Equivalent approved by Engineer
8	ANTI CORROSIVE PAINT	JOTUN	ICI	NIPPON	Or other Equivalent approved by Engineer

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		Brand 1	Brand 2	Brand 3	
F <u>CHEMICALS</u>					
1	Termite Proofing	Biflex	DURBAN TC	-	Or other Equivalent approved by Engineer
2	Bitumen 10/20	HyGrip	PECOGUM	Attock Oil	Or other Equivalent approved by Engineer
3	Water Proofing ADMIXTURES / Membrane	Aquafin	HyGrip	-	Or other Equivalent approved by Engineer
4	POLISH / STAIN + SEALER	ICI	Jaffer Brothers	-	Or other Equivalent approved by Engineer
5	POWDER COATING	JOTUN	National Paints (U.A.E.)	-	Or other Equivalent approved by Engineer
G <u>WINDOWS COVERS</u>					
1	Blinds	THE PROTECTORS	MARVI	LOCAL MAKE	Or other Equivalent approved by Engineer
H <u>CEILING</u>					
1	False Ceiling-Gypsum Board (With All Accessories)	LOCALLY AVAILABLE			Or other Equivalent approved by Engineer
2	False Ceiling - Metal Pan (With All Accessories)	DENMARK	HOLLAND	-	Or other Equivalent approved by Engineer
3	False Ceiling - Aluminium False Ceiling (With All Accessories)	DENMARK	HOLLAND	-	Or other Equivalent approved by Engineer
I <u>MISCELLANEOUS</u>					
1	TIRE KILLERS	SOFAB	-	-	Or other Equivalent approved by Engineer
2 ELECTRICAL WORKS					
1	L.V Switchgear / Distribution Panels	Siemens	MA Engineering	Sun beam Engineering	Or other Equivalent approved by Engineer
2	LV Circuit Breakers	Merlin Gerlin / Hager France	Terasaki Japan	GE European	Or other Equivalent approved by Engineer
3	GI / Steel Conduits & Accessories	IIL	Hilal Industries	-	Or other Equivalent approved by Engineer
4	Cable Trays / Ladder & Accessories	Ezzi Engineering	Electroline	Yovatech	Or other Equivalent approved by Engineer
5	Lighting Fixtures	Philips	Britlite	Global Lighting & Systems	Or other Equivalent approved by Engineer
6	Emergency Lights / Conversion Kits / fire Exit Sign Lights	Chlorde Bardic	Meniver	Gents	Or other Equivalent approved by Engineer
7	Fire Alarm System	Gent / Esser / Ziton UK	Notifier USA	Inim Italy	Or other Equivalent approved by Engineer
8	CCTV System	Samsung	Bosch	Aventura / Havron / Cametron, Korea	Or other Equivalent approved by Engineer
9	LV/MV Power Cables	Pakistan Cables	Poineer Cables	Newage Cables	Or other Equivalent approved by Engineer
10	Cable Lugs	3M	Raychem	-	Or other Equivalent approved by Engineer
11	Switches, Sockets & Dimmers	Clipsal Australia	MK UK	ABB France	Or other Equivalent approved by Engineer
12	MS Back Boxes	Clipsal Australia	MK UK	-	Or other Equivalent approved by Engineer
13	Floor Pull / Service Outlet Boxes	Clipsal Australia	MK UK	-	Or other Equivalent approved by Engineer
14	Active Green Earth	ERICO USA	-	-	Or other Equivalent approved by Engineer
15	Voice & Data Communication System	3M / Panduit / Sysitimax - USA	Clipsal Australia	-	Or other Equivalent approved by Engineer
16	Co-axial Cables	3M / Saxton USA	Pony Japan	Clipsal Australia	Or other Equivalent approved by Engineer

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		Brand 1	Brand 2	Brand 3	
17	Electronic Ballasts	Philips	Schwabe	Atco	Or other Equivalent approved by Engineer
18	Lamps	Philips	Osram	-	Or other Equivalent approved by Engineer
19	PVC PIPE/ Conduits & Accessories	Dadex	Galco	-	Or other Equivalent approved by Engineer
20	Lighting Control Relays / CT Contractor	MG France	Chint	-	Or other Equivalent approved by Engineer
21	MDBs / DBs	Siemens	RA Engineering	PESCO	Or other Equivalent approved by Engineer
22	Lighting Protection System	Erico	Satelit+G	-	Or other Equivalent approved by Engineer
23	Elevators/Escavator	Schindler Switzerland	Pickerings Lifts England	Kone (Finland) / USA	Fuji, Japan
24	H.T Panel	Siemens	Schneider	A.E.G	Or other Equivalent approved by Engineer
25	Transformers	Siemens	Schneider	A.E.G	Or other Equivalent approved by Engineer
26	Fans / Exhaust Fans	Climax	Millat	Pak Fan	Or other Equivalent approved by Engineer
27	Diesel Engine Generator / Canopy / Amf Panel & Synchronizer	Catter Pillar	F.G Willson	Perkins	Or other Equivalent approved by Engineer
28	Air Conditioner	Mitsubishi	LG	ACSON	Or other Equivalent approved by Engineer
3 HVAC WORK					
1	Air Handling Unit	York	Carrier	Mcquay / Midea	Or other Equivalent approved by Engineer
2	Fan Coil Unit	York	Carrier	Mcquay / Midea	Or other Equivalent approved by Engineer
3	Air Cooled Screw Chiller	York	Carrier	Tane	Or other Equivalent approved by Engineer
4	Flexible Rubber Duct Connection	Imported	-	-	-
5	Chilled Water Pumps	Lowara	KSB	Grundfoss	Or other Equivalent approved by Engineer
6	Motor	Siemens	Lowara	Eabra	Or other Equivalent approved by Engineer
7	M.S. Shedule 40 Seamless Pipe	Huffaz, Pakistan	Imported	-	Or other Equivalent approved by Engineer
8	Chilled water Insulation	Affico	Kimco	-	Or other Equivalent approved by Engineer
9	Duct Insulation	Affico	Kimco	-	Or other Equivalent approved by Engineer
10	Flexible Duct	Affico	Kimco	-	Or other Equivalent approved by Engineer
11	Chemical For Chilled Water	Orient Services	Prime Chemical	-	Or other Equivalent approved by Engineer
12	Air Curtains	McQuay	Shan Industries	Airtech	Or other Equivalent approved by Engineer
13	Fresh Air Fan & Exhaust Air Fan	Nicotra	Penberry	-	Or other Equivalent approved by Engineer
14	Valves	Econosto	Tozzan	-	Or other Equivalent approved by Engineer
15	Balancing valves	Econosto	Tozzan	-	Or other Equivalent approved by Engineer
16	Flow Switch	German Make	USA Make	-	Or other Equivalent approved by Engineer
17	Auto Air Vent	Taco USA	ITT Bell	Gossete	Or other Equivalent approved by Engineer
18	Flexible Connector	Econosto	Tozzan	-	Or other Equivalent approved by Engineer
19	Pressure Gauge	German Make	USA Make	-	Or other Equivalent approved by Engineer
20	Thermometer	German Make	USA Make	-	Or other Equivalent approved by Engineer

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Sr No.	Materials	Approved Manufacturers / Suppliers			Remarks
		Brand 1	Brand 2	Brand 3	
21	G.I sheets	Pakistan Steel	-	-	Or other Equivalent approved by Engineer
22	Upvc Pipe & Fitting(SCH 40)	AGM	Dadex	Pak Arab	Or other Equivalent approved by Engineer
23	G.I Pipe	IIL Pakistan	-	-	Or other Equivalent approved by Engineer
24	G.I Fitting	HE	TG China	-	Or other Equivalent approved by Engineer
25	MCC & DBs	Libra	Sunbeam	Ezzi Engineering	Or other Equivalent approved by Engineer
26	Cables & Wires	Pakistan cable	Pioneer	AGM	Or other Equivalent approved by Engineer
27	Pvc Conduit	Galco	Dadex	-	Or other Equivalent approved by Engineer
28	Air Devices	Mehran	Steel Craft	Thermac	Or other Equivalent approved by Engineer
29	Supports & Anchors	-	-	-	Fabricated as per approved sample
30	Gaskets	Rawl Plug Co, UK	Ficher Germany	Hilti UK/ Germany	Or other Equivalent approved by Engineer
31	Vapour barrier coating	Foster USA	Zahabiya Pakistan	-	Or other Equivalent approved by Engineer
32	Duct Sealant	Zahabiya Pakistan	-	-	Or other Equivalent approved by Engineer
33	Air Cushion	Imported	-	-	Or other Equivalent approved by Engineer
34	Paints	ICI	Berger	-	Or other Equivalent approved by Engineer
4 PLUMBING WORKS					
1	European Type W.C. Pan	Porta	-	-	Or other Equivalent approved by Engineer
2	Wash Basin (Pedestal type)	Porta	-	-	Or other Equivalent approved by Engineer
3	Wash Basin (Under Counter)	Porta	-	-	Or other Equivalent approved by Engineer
4	Asian WC	Porta	-	-	Or other Equivalent approved by Engineer
5	Flash tank for AWC	Porta	-	-	Or other Equivalent approved by Engineer
6	Urinal	Porta	-	-	Or other Equivalent approved by Engineer
7	Sink (Local make)	Asia	-	-	Or other Equivalent approved by Engineer
8	Basin mixture with pop-up waste	Zilver (E-D135)	-	-	Or other Equivalent approved by Engineer
9	Sink Mixture	Zilver (GX9615)	-	-	Or other Equivalent approved by Engineer
10	C.P. waste for sink	Zilver	-	-	Or other Equivalent approved by Engineer
11	Bibcock (Chrome)	Zilver (E-S03F)	-	-	Or other Equivalent approved by Engineer
12	Double Bibcock (Chrome)	Zilver (E-S08)	-	-	Or other Equivalent approved by Engineer
13	Tee cock (Chrome)	Zilver (GX7012)	-	-	Or other Equivalent approved by Engineer
14	Muslim shower (Chrome)	Zilver (E-S08)	-	-	Or other Equivalent approved by Engineer
15	Flexible chain (Chrome)	Zilver (E-S08)	-	-	Or other Equivalent approved by Engineer
16	Flexible chain supports wall bracket	Zilver (Robo803-2)	-	-	Or other Equivalent approved by Engineer
17	Bottle Trap	Zilver (E-X024)	-	-	Or other Equivalent approved by Engineer
18	Paper Holder	Zilver (033-2)	-	-	Or other Equivalent approved by Engineer

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Sr No.	Materials	Approved Manufacturers / Suppliers			Remarks
		Brand 1	Brand 2	Brand 3	
19	Towel Rail	Zilver (033-4)	-	-	Or other Equivalent approved by Engineer
20	Coat hook	Zilver (033-1)	-	-	Or other Equivalent approved by Engineer
21	Soap Dispenser	Zilver (302C)	-	-	Or other Equivalent approved by Engineer
22	Soap Dish	Zilver (033-6)	-	-	Or other Equivalent approved by Engineer
23	Hand Dryer	Zilver (20004S)	-	-	Or other Equivalent approved by Engineer
24	Polypropylene Pipe fittings (Water)	Vesbo	Cosmaplas	-	Or other Equivalent approved by Engineer
25	Stainless steel Pipe fittings (Water)	Imported	-	-	Or other Equivalent approved by Engineer
26	Stainless steel Pipe fittings (drainage)	Imported	-	-	Or other Equivalent approved by Engineer
27	Cast iron pipe & fittings	Alpine	-	-	Or other Equivalent approved by Engineer
28	UPVC Pipe (Class "B")	Marly	Tarain	-	Or other Equivalent approved by Engineer
29	UPVC Pipe Fittings	Marly	Tarain	Hepworth	Or other Equivalent approved by Engineer
30	Clean-out UPVC	Alpine	-	-	Or other Equivalent approved by Engineer
31	Clean-out cast iron	Alpine	-	-	Or other Equivalent approved by Engineer
32	Floor Drain / Floor Gully	Marly	Tarain	Hepworth	Or other Equivalent approved by Engineer
33	Floor Drain stainless steel	Alpine	-	-	Or other Equivalent approved by Engineer
34	Gully Trap Cast Iron	Alpine	GMP	-	Or other Equivalent approved by Engineer
35	Gully Trap stainless steel	Alpine	GMP	-	Or other Equivalent approved by Engineer
36	Anchor / Fasteners	Hillti	-	-	Or other Equivalent approved by Engineer
37	Valves and Strainers	Watts	Ecnosto	-	Or other Equivalent approved by Engineer
38	Rubber hose as per specification	Imported	-	-	Or other Equivalent approved by Engineer
39	Teflon Tape	Imported	-	-	Or other Equivalent approved by Engineer
40	Stainless steel channel & grating	Alpine	GMP	-	Or other Equivalent approved by Engineer
41	Cast iron grating	Alpine	GMP	-	Or other Equivalent approved by Engineer
42	Hot Water circulation pump	Ggrandfos	Nochi	Pantair	Or other Equivalent approved by Engineer
43	Manhole Frame & Cover (CI)	Alpine	GMP	-	Or other Equivalent approved by Engineer
44	Cowl	Marly	Tarain	Hepworth	Or other Equivalent approved by Engineer
45	Rubber Foam Insulation	Aero flex	-	-	Or other Equivalent approved by Engineer