

Technical Specification

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1 –EXCAVATION, EARTH WORKS AND ROAD WORKS

1.1 GENERAL

The Contractor shall carry out all excavations, filling, backfilling and all other earthworks required in whatever material may be encountered.

The Works shall be executed accurately to the dimensions, levels, lines and profiles as indicated on the drawings or directed by the Engineer.

The Contractor shall reconstruct to the proper level and profile any filled areas which settle or spread during the execution of the work or during the maintenance period.

The Contractor shall drain and dewater the underground water to a level below the excavation by lowering the water table with a proper drainage and dewatering system approved by the Engineer.

1.2 SOIL INFORMATION

The Contractor shall be deemed to have visited the Site of Works and satisfied himself as to the nature of the ground and made him conversant with the local conditions to be encountered during the execution of the Contract. The contractor is requested to perform a soil test to determine the nature and bearing capacity of the soil surface if indicated clearly in the contract documents.

1.3 MATERIALS

1.3.1 Backfill and Fill

Backfill and fill shall be a structurally sound material such as; gravel or native soil free of rocks with size more than 5cm, lumps, vegetables and other organic materials obtained from suitable excavated material and/or from approved borrow pits.

1.3.2 Water

Water shall be clean potable water as specified under “Concrete Work”

1.3.3 Concrete

Concrete used as fill for making up the correct level areas of over-excavation shall be, where required by the Engineer of Class “B” as specified under “Concrete Work”.

1.3.4 Hardcore

Hard-core under floor paving, etc. (Where shown on the drawings or as directed by the Engineer) shall consist of tough, sound and durable rubble stones (maximum 150mm), free from coatings, clays, seems or flows of any character. Fine aggregate for blinding the interstices of hard-core bed shall be as described in “Concrete Work”.

1.3.5 Agricultural Soils, Gravel and Sand Fill

Agricultural soil shall be first choice top soil rich in organic materials and free from roots, stones

and rubbish suitable for plantation and shall be obtained from an approved source. Gravel fill shall consist of graded gravel 50mm down to 20mm and blinded with clean coarse sand.

1.4 SITE PREPARATION

1.4.1 Existing Public Utilities

The Contractor shall ascertain the whereabouts of all existing public utilities on the site, both above and below ground. Such utilities shall be removed, sealed or rerouted in a manner prescribed by the Public Authorities concerned at the Contractor's own expense. The Contractor shall also be held responsible for all damages entailed on any of the public utilities adjacent to the Site resulting from the Works.

1.4.2 Removal of Existing Structures and Other Obstructions

This work shall include, but not be limited to, the removal of existing structures and other obstructions interfering with the works. The salvaging of any of these materials for the use of the Employer shall be as directed by the Engineer and unwanted materials shall be disposed off the Site in a satisfactory manner at the Contractor's expense.

1.4.3 Cleaning and Grubbing

The Contractor shall perform the clearing and grubbing (if any) of top soil consisting mainly of loose soil, vegetable and organic matters, drift sand, unsuitable soil and rubbish by scarifying the areas to be excavated to a minimum depth of 300mm from the natural ground level. All materials resulting from the above operations shall be removed from the Site, loaded and transported and off loaded spread and leveled to approved dumps as directed by the Engineer.

1.5 SETTING-OUT

The Contractor shall stakeout the work as shown on the Drawings and secures the Engineer's approval of his stakeout before proceeding with construction. If, in the opinion of the Engineer, modification of the line or grade is advisable before or after stake-out the Engineer will issue detailed instructions in writing to the Contractor for such modification and the Contractor shall revise the stake-up for further approval in accordance with the relevant Clause of the Conditions of Contract.

1.6 EXCAVATION

1.6.1 General

Excavation in any material whatsoever found including rock to reduce levels and to form foundations, bases, trenches, septic tanks, pools, pits and the like to depths shown on the drawings or as directed by the Engineer.

Completely remove all existing obstructions in the line of excavations such as wall, slabs, curbs, steps and the like.

When removing any trees and roots with diameter more than 80 mm, should be rooted out to a depth of up to 500 mm then re-filled with approved material in layers. Also when mass rocks and other obstacles are found, the same mechanism of rooting and backfilling should be carried out at the expense of the contractor .

Trimming the sides of excavations to the required profiles and levels as well removing all loose

material should be executed prior to consecutive process.

Level and well ram and consolidate surface of ground and bottom of all excavations to receive concrete foundations, beds, etc.

Bottoms of excavations shall be approved by the Engineer's Representative before any concrete is laid.

Should the Contractor excavate deeper than is shown on the drawings or required by the Engineer's Representative, to obtain a solid bottom, he must fill up excavation to the proper level with concrete Class B at his own expense.

1.6.2 Excavation in Rocks

Rock shall be defined as boulders, exceeding 0.25m³ in volume or any kind of stone or rock formation which in the opinion of the Engineer's Representative requires for its removal drilling and blasting wedging, sledging or barring or breaking up with power-operated hard tool..

The definition shall exclude any soft or disintegrated rock which can be removed with a hard pick or mechanical excavator or shovel or loose, shaken or previously blasted rock or broken stone in rock fillings or elsewhere.

Blasting by explosives shall not be permitted without obtaining the written approval of the Engineer. If such approval is given the Contractor shall be solely responsible for:-

1. Obtaining permits, keeping record.
2. Storing permits, keeping record.
3. Taking all necessary precautions in compliance with the regulations pertinent to the use of Explosives.
4. Any damage that may occur due to the blasting operations where rock is encountered it shall be carefully excavated and the Contractor shall not be entitled to additional compensation unless otherwise specified in the Bills of Quantities.

1.7 PLANKING AND STRUTTING

The terms "planking and strutting" will be deemed to cover whatever methods the Contractor elects to adopt for shoring the sides of excavation and also for planking and strutting the excavations against the sides of adjoining buildings, public roadways, etc... The Contractor will be held responsible for shoring the sides of all excavations, adjoining building and the like and no claim for additional excavation, concrete or other material or workmanship will be considered in this respect.

In the event of any collapse of the excavations, the Contractor shall re-excavate and re-instate such excavations at his own expense. No additional excavations will be paid or should the Contractor batter the sides of the excavations.

1.8 KEEPING EXCAVATIONS FREE FROM WATER

All excavations shall be kept clear of water by pumping or bailing or by well-point dewatering, but the latter system shall not be employed if any danger exists of withdrawing water from the foundations of the adjoining buildings and such water shall be discharged clear of the works and the method adopted shall in no way contravene the regulations of the Local Authorities.

The system or systems to be employed shall be approved by the Engineer. Such approval if given shall not waive the Contractor's responsibilities and liabilities under the Contract.

Particular attention shall be paid to the installation of sheeting and shoring as may be necessary for the protection of the work and for the safety of personnel and public.

1.9 STORING OF SUITABLE EXCAVATED MATERIAL

During excavation, materials suitable for backfill and fill shall be stockpiled on the Site at sufficient distance from the sides of the excavation to avoid overloading and prevent caverns or mixing with the concrete during the construction of foundations.

1.10 DISPOSAL OF UNSUITABLE AND SURPLUS EXCAVATED MATERIAL

Upon the order of the Engineer, all unsuitable and surplus excavated materials shall be immediately removed.

Loaded and transported off the site area by the Contractor to approved dumps and he shall abide by the relevant local regulations.

1.11 EXCAVATION FOR FOUNDATIONS AND SUB-STRUCTURE

The Contractor shall excavate to reach a suitable strata accepted by the Engineer or as shown by the Drawings during excavation for foundations, the bottom layer of excavation of minimum 200mm in thickness, shall be left undisturbed and subsequently removed manually only when the concrete in blinding is about to be placed in order to avoid softening or deterioration of the surfaces of the excavation.

Bottom of all excavations shall be formed to correct levels as shown on the Drawings or as directed in writing

1.12 EXCAVATION FOR TRENCHES

1.12.1 General

The Contractor shall provide all forms and bracings, and excavate trenches necessary to install all drainage, sewer water supply, electrical and telephone cables to the lines and grades complete in strict conformity with these specifications, applicable drawings and/or as directed by the Engineer.

1.12.2 Grading

The bottom of the trenches shall be accurately graded to provide uniform bearing and support for each section of the pipe on undisturbed soil at every point along its length, except for the portions of the pipe where it is necessary to excavate for bell-holes and for proper sealing of joints. Bell-holes and depressions for joints shall be dug after the trench has been graded.

Care shall be taken not to excavate below the depths indicated. Where rock shall be excavated to the required depth, uneven surface of the bottom trench shall be excavated 15mm deeper. Such depth, if in rock, shall be back-filled with concrete Class "B" as specified under "Concrete Work" and when in earth, shall be back-filled with approved sand at the Contractor's own expense.

Whenever unstable soil, which in the opinion of the Engineer, is incapable of properly supporting the pipe or duct is encountered in the bottom of the trench, such soil shall be removed to the depth

required and the trench back-filled to the proper grade with sand, fine gravel or other suitable material approved by the Engineer.

The width of the trench for Drainage at and below the top of the pipe shall be such that the clear space between the barrel of the pipe and the trench wall shall be 20mm on each side of the pipe. The width of the trench above that level may be as wide as necessary for sheeting and bracing and the proper performance of the work.

Trench for Water Supply System shall be of a depth to provide minimum cover over the top of 300mm and avoid interference of water lines with other utilities. Width of trench shall be a maximum of 200mm on each side of the pipe.

The width of trenches for electrical and telephone cables shall be as specified in their relative section. Banks may be sloped or widened to facilitate placement of cables, but not to an extent that will cause interference with other utilities.

Excavation for appurtenant structures for manholes, septic tank, percolating pit and similar structures shall be sufficient to allow a minimum of 300mm of clear space between their outer surfaces shoring timbers which may be used to protect the banks.

1.13 BACKFILL AND FILL

Approved suitable excavated material as specified under “MATERIALS” shall be used in the backfilling and filling next to footings, foundations underground structures, under sub-floors, etc... and shall be laid in layers not exceeding 250mm and compacted with compaction equipment, as approved by the Engineer. Moisture content shall be adjusted as directed by the Engineer and 97% of dry weight compaction accordance to ASTM: D1557-70 shall be achieved.

At least one sample of core pit must be taken from each 100 m² in buildings for each layer of backfill.

Heavy equipments should not work or pass through within the structural boundary of the building during the backfilling process.

Should the quantity of the excavated material be not sufficient for the process of backfill and fill, the Contractor shall obtain the quantity required of such backfill and fill from approved borrow pits and transport same to the Site of work at his own expense if not itemized in the bills of quantities.

No backfill shall be executed until the footings, foundations, etc., have been inspected, measured and approved by the Engineer.

Trenches should be backfilled until all required tests are performed and until the Engineer has verified that the Utility systems have been installed in accordance with the Specifications and the Drawings. The backfill in the pipe zone must be placed and completed so as to provide and maintain adequate and even support around the pipe wall. If mechanical compaction equipment is need, care must be taken to prevent direct contact with the pipe.

1.14 BED OF HARDCORE

The bed of hardcore where shown on the Drawings or as directed by the Engineer shall be of an approved rubble stone as specified under “MATERIALS” and shall be laid under floor paving. The rubble stone for hardcore shall be hand-packed with sharp edge upward and wider (natural face) laid on the ground. The interstices of hardcore bed shall be filled with approved fines, wetted

sufficiently and well consolidated. The thickness of the hardcore bed shall be as shown on the Drawings.

1.15 PLACING OF AGRICULTURAL SOIL, GRAVEL AND SAND

The agricultural sifted soil as specified under “MATERIALS” shall be spread in the flower boxes and beds to the thickness shown on the Drawings after thorough watering and on a bed of 100mm thick graded gravel blinded with clean coarse sand to the satisfaction of the Engineer.

1.16 EXCAVATIONS OF CUTTINGS IN CARRIAGE WAYS

1. Hauling of material from cuttings or borrow pits to the embankments or other areas of fill shall proceed only when sufficient compaction plant is operating at the place of disposition to ensure compliance with the requirements of specifications.
2. Any excess depth excavated below formation level tolerance shall be made good by back filling with suitable material of similar characteristics to that removed, compacted in accordance with specification.
3. The slopes of cuttings shall be cleared of rock fragments which move when prized by a crow bar.
4. Construction traffic shall not use the surface of the bottom of a cutting unless the cutting is in rock or the Contractor maintains the level of the bottom surface at least 30cm above formation level. Any damage to the sub-grade arising from such use of the surface shall be made good by the Contractor at his own expense, with material having the same characteristics as the material which has been damaged.

1.17 FILLING AND FORMING OF EMBANKMENTS AND OTHER AREAS OF FILL

1. Embankments and other areas of fill shall be formed of material defined as “suitable material”
2. All earthworks material placed in or below embankments, below formation level in cuttings or else wherein the works shall be deposited and compacted as soon as practicable after excavation in layers of thickness appropriate to the compaction plant used or as a permitted departure therefore. Embankments shall be built up evenly over the full width and shall be maintained at all times with a sufficient camber and a surface sufficiently even to enable surface water to drain readily from them. During the construction of embankments, the Contractor shall control and direct constructional traffic uniformly over their full width. Damage to compacted layers by constructional traffic shall be made good by the Contractor.
3. In areas of shallow filling where after removal of topsoil the ground level is within 30cm of formation level constructional traffic shall not use the surface unless the Contractor brings up and maintains the surface level at least 30cm above formation level. Any damage to the sub-grade arising from such use shall be made good by the Contractor at his own expense with material having the same characteristics as the damaged materials.

1.18 COMPACTION OF EMBANKMENTS AND OTHER AREAS OF FILL

- 1 All materials used in embankments and as filling elsewhere shall be compacted as soon as practicable after deposition.
- 2 Variation from the method of compaction stated below or the use of plant not included therein will be permitted only if the Contractor demonstrates at site trials that a state of compaction is achieved by the alternative method equivalent to that obtained using the approved methods. This procedure shall be agreed and approved by the Engineer.
- 3 The Engineer may at any time carry out comparative field density tests determined in accordance with B. S. 1377 test No. 14 on material, which he considers has been, inadequately compacted. If the test results when compared with the results of similar tests made on adjacent approved work in similar materials carried out in accordance with specification, show the state of compaction to be inadequate and this held to be due to failure of the Contractor to comply with the requirements of the Contract, the Contractor shall carry out such further work as the Engineer may decide is required to comply with the terms of the Contract.
- 4 The Contractor shall not less than 24 hours before he proposes to carry out compaction processes during periods of overtime, apply in writing to the Engineer for permission to do so.

1.19 MEASUREMENTS

All measurement of cut, backfill and fill of different materials should be using the engineering calculations or otherwise mentioned in the other contract documents or as directed by the Engineer.

2 -CONCRETE WORKS

2.1 SCOPE

This section describes and specifies work required for plain and reinforced concrete, including formwork intended to be used for the Project under the Contract in accordance with the Drawings, Bills of Quantities and as directed by the Engineer.

At the beginning of each month, the Contractor shall submit to the Engineer his concreting programme for that month, stating the pouring dates, so that adequate checking and supervision can be provided before and during the pouring operation. No pouring shall be allowed unless the Engineer has been given a week-advanced notice of the intention to pour.

2.2 APPLICABLE TESTS AND CODES

Prior to commencement of concrete work, the Contractor shall submit samples to the Engineer before sending them to the laboratories for testing, to establish the probability of the materials passing tests for specified requirements.

After the Engineer is convinced that the samples with their sources are truly representative samples and sufficient materials are available on the Site for the completion of all concrete works under the Contract, the samples shall be approved and sent to the laboratories for testing. Upon the Engineer's request, the Contractor shall have the tests made, at his own expense in the laboratories approved by the Engineer.

All concrete aggregates, cement and water shall be sampled and tested as frequently as deemed necessary by the Engineer. All tests samples shall be obtained in accordance with the latest editions of the American Society for Testing and Material (ACI) Code or any equally approved standard.

2.3 MATERIALS

2.3.1 Cement

2.3.1.1 General

Cement shall be Portland Type originating from approved manufacturers in sealed and labeled bags, each 50 kgs. Not capacity, name and brand of the manufacturer shall plainly be identified thereon and delivered to the site in good condition. Cement delivered in bulk shall be accepted only if a central mixing plant is used. The Quality of cement shall conform to the Standard Specification for PORTLAND CEMENT of ASIM Designation: C150-74 Type I- for use in general concrete construction and Type V- for use when high sulphate resistance is desired.

2.3.1.2 Storage of Cement

All cement shall be stored in suitable weatherproof and approved storage sheds which will protect the

cement from dampness. Storage sheds shall be erected in locations approved by the Engineer.

Provision for storage shall be ample, and the consignment of cement as received shall be separately stored in such a manner as to provide easy access for the identification and inspection of each consignment. Cement shall be used in the order of its delivery to site, new deliveries shall not be used unless the cement from earlier deliveries has been completely used. Stored cement shall meet the test requirements at any time after storage when a re-test is ordered by the Engineer all the expense of the Contractor.

The Contractor shall keep accurate records of the deliveries of cement and of its use in the work. Copies of these records shall be supplied to the Engineer in such form as may be required.

2.3.1.3 Rejection

The Contractor shall notify the Engineer of dates of delivery so that there will be sufficient time for sampling the cement either at the mill or upon delivery.

The provisional acceptance of the cement at the mill shall not deprive the Engineer of the right to reject on a reset of soundness at the time of delivery of the cement to the site.

Package of cement varying by 5 percent or more from the specified weight shall be rejected and if the average weight of packages in any consignment, as shown by weighing 50 packages taken at random, is less than that specified, the entire consignment shall be rejected and the Contractor shall remove it forthwith from the Site at his own expense and replace it with cement of satisfactory quality.

Stale cement or cement reclaimed from cleaning bags shall not be used and cement which for any reason has become partially set, or contains lump or caked cement, shall be rejected.

2.3.2 Aggregates

2.3.2.1 General Requirements

All aggregates shall consist of tough, hard, durable uncoated particles. The Contractor shall be responsible for the processing of this material to meet the requirements of the Specifications. Approval of aggregate quality and/or gradation shall not waive the responsibility of the Contractor to provide concrete of having the minimum strength specified.

2.3.2.2 Storage

Coarse and fine aggregates shall be delivered and stored separately on site in such a manner as to prevent segregation and contamination or the admixture of foreign materials. Aggregate which has become segregated or contaminated with foreign matter during storage or handling will be rejected and shall be removed and replaced with material of acceptable quality at the Contractor's expense. Aggregates of the quality and colour selected shall be stored in sufficient quantity to avoid interruption of concreting work at any time.

2.3.3 Fine Aggregate

2.3.3.1 General Requirements

All fine aggregate shall conform to Standard Specification for Concrete Aggregates of ASIM Designation: C-33 and also to the detailed requirements give in Table 2-1 (appended here below). It shall not contain harmful materials such as iron pyrites, coal, mica, and shale. Alkali, coated grains, or similar laminated materials such as soft and flaky particles, or any material which may attack the reinforcement, in such a form and in sufficient quantity to affect adversely the strength and durability of the concrete. Fine Aggregate passing sieve No. 4 shall not contain any voided shells. Fine aggregates shall be washed thoroughly with de-mineralized water to ensure compliance with the appropriate requirements and limitations of the specifications.

The Contractor shall provide and maintain for this proposes sand-washing plant and equipment.

Fine Aggregate from different sources of supply shall not be mixed or stored in one pile nor used alternately in the same class of construction or mix.

Table 2-1: Detailed requirements for Fine Aggregate

Sieve Analysis	
Grading Sieve	Percent of Passing
3/8	100
No. 4	95- 100
No. 8	80- 100
No. 16	50- 85
No. 30	25- 60
No. 50	10- 30
No. 100	2- 10
No. 200	0- 3
Fineness modulus	2.50- 2.15
Organic Impurities	The color shall have an intensity not darker than two-thirds the intensity of the standard color solution. (Not darker than Plate 2 as determined by the Standard Method of Test for Organic Impurities in Sands for Concrete of ASTM Designation C - 40
Chlorides soluble in dilute Nitric Acid	Not more than 0.10 percent by weight when expressed as sodium chloride (NACL).
Total Acid soluble sulphates	Not more than 0.50 percent by weight when expressed as sulphur trioxide(SO ₃)
Silt	Not more than 2 percent
Mortar strength	Compression ration less than 95 percent
Soundless	Weighted average loss when subjected to 5 cycles of the soundless test using magnesium sulfate, not more than 10 percent

2.3.4 Coarse Aggregate

2.3.4.1 General Requirements

All coarse aggregate for concrete shall conform to Standard Specifications for Concrete Aggregates of ASTM Destination: C-33 Coarse aggregate shall consist of gravel, crushed gravel, or crushed stone, having hard, strong durable pieces, free from adherents. It shall not contain harmful materials such as iron pyrites, coal, mica, alkali, laminated materials, or any material which may attack the reinforcement, in such a for or in sufficient quantity to affect adversely the strength and durability of the Concrete. Coarse aggregates shall be washed thoroughly with de-mineralized water to ensure compliance with the appropriate requirements and limitations of the specifications. The Contractor shall provide and maintain for this purpose approved washing plant and equipment.

2.3.4.2 Deleterious Substances

The amount of deleterious substances shall not exceed the following limits:

Max. Permissible Limit Percent by Wt.:

Soft fragments	2.00
Coal and lignite	0.50
Clay lumps	0.25
Materials passing the No.200 sieve	1.00
Thin or clognated pieces (length greater than 5 times average thickness)	4.00
Other local deleterious substances	0.00
Chlorides soluble in dilute Nitric acid when expressed as Sodium Chloride (NaCL)	0.05
Total acid soluble sulphates when expressed as sulphur trioxide (SO ₃)	0.50

2.3.4.3 Percentage of Wear

Coarse aggregate shall conform to the following requirements:

Percentage of wear, Los Angeles test, not more than (30)

2.3.4.4 Grading

Coarse aggregate, when tested according to the requirements of ASTM, shall meet the following gradation and shall be uniformly graded within the limits stated in Table 2-2 here below:

Table 2-2: Grading Analysis for Coarse Aggregate

ASTM	Percentage by Weight Passing		
	Grading (3/4" to No.4)	Grading (1" to No.4)	Grading (2" to No.4)
2 ½ inch	--	--	100
2 inch	--	--	95- 100
1 ½ inch	--	100	--
1 inch	100	95- 100	35- 70
¾ inch	95- 100	--	--
½ inch	--	25- 60	10- 30
3/8 inch	20- 55	--	--
No. 4	0- 10	0- 10	0- 5
No. 8	0- 5	0- 5	--
No. 200	0- 1	0- 1	0- 1

2.3.5 Combined Aggregate

Approved fine and coarse aggregate on each batch of concrete shall be combined in proportions as approved by the Engineer, according to test results giving the required compressive concrete stress as specified per type of Concrete.

The combined aggregate gradation using the ¾ in. to No. 4 gradation shall be used for concrete members with reinforcement to close or permit proper placement and consolidation of the concrete. Change from one gradation to another shall not be made during the progress of the work unless approved by the Engineer. Such changes are admitted only after being proved by test results.

2.3.6 Aggregate for Mortar

2.3.6.1 General Requirements

Aggregate for mortar shall conform to the Standard Specification for Aggregate for Masonry Mortar of ASTM Designation: C-144 and shall consist of hard, strong, durable uncoated mineral or rock particles, free from injurious amounts of organic or other deleterious substances.

2.3.6.2 Organic Impurities

Fine aggregate for mortar when subjected to the Calorimetric test for organic impurities and producing a color darker than the standard color shall be rejected.

2.3.7 Water

2.3.7.1 Quality of Water

Water for mixing of concrete shall be fresh, clean and free from injurious amounts of oil, acid, or any other deleterious mineral and/or organic matter. It shall not contain chlorides such as sodium chloride in excess of 700 ppm. It shall not contain any impurities in amount sufficient to cause a change in the time of setting of Portland Cement of more than 10 percent, nor a reduction in compressive strength of mortar of more than 5 percent compared to results obtained with distilled water.

The PH of the water for mixing and curing of concrete shall not be less than PH 4.5 or more than PH 8.5.

2.3.7.2 Tests for Water

When required by the Engineer the quality of the mixing water shall be determined by the Standard Method of Test for quality of water to be used in concrete, as specified in B.S. 3148: 1959 Tests for Water for Making Concrete.

In sampling water for testing, care shall be taken to ensure the containers are clean and that samples are representative.

2.3.7.3 Admixtures

Admixtures in concrete shall be used only when approved by the Engineer and shall conform to the requirements of the ASTM Standard Specifications Designation c-494-68 for Water Reducing and Retarding Admixtures, and C-260-69 for Air entraining Admixtures for Concrete, and waterproofing and watertight.

The Contractor shall ensure that the admixture supplied for use in the work is equivalent in

composition to the admixture subjected to test under this Specification. Tests shall be made whenever practicable using the cement, aggregates, admixtures proposed for specific work, because the specific effects produced by chemical admixtures may vary with the properties of the other ingredients of the concrete.

The specific effects produced by chemical admixtures may vary with the properties of the other ingredients of the concrete.

Admixture that contains relatively large amounts of chloride shall accelerate corrosion of reinforcing steel and shall be the cause of rejection.

Water reducing and retarding admixtures shall comply with the physical requirements of ASTM tests and shall be approved in writing by the Engineer.

When the admixture is delivered in packages or containers, the proprietary name of the admixture, the type and the weight or volume shall be plainly marked thereon. Similar information shall be provided in the shipping advises accompanying packaged or bulk shipments of admixtures.

The admixture shall be stored in such a manner as to permit easy access for proper inspection and identification of each shipment, and in a suitable weather-tight store that will protect the admixture from dampness.

Costs of such admixtures, sampling and testing shall be at the Contractor's expense.

2.4 COMPOSITION OF CONCRETE

The cement content, coarse aggregate size, water content, consistency and the approximate weights of fine and coarse aggregate (saturated surface-dry basis) for the class of concrete shall be within the requirements of Table 2-3 (I) and Table 2-3 (II) Below.

The weight of fine and coarse aggregate given in Table 2-3 (II) below is based on the use of aggregates having bulk specific gravities, in a saturated surface-dry condition, 2.65-5%. For reasonably well graded materials of normal physical characteristics, the use of the below indicated proportions, together with specified water content to obtain the required consistency, will result in concrete of the specified cement content, plus or minus two (2) percent.

For aggregate having specified gravities outside the ranges indicated in the Table 2-3 (II) below, the weights shall be corrected by multiplying the weights shown in Table 2-3 (II) below by the ration of the specific gravity of the aggregate and 2.65.

The relative weights of fine and coarse aggregate per sack of cement given in Table 2-3 (II) below are based on the use of natural sand having a fineness modulus within the range of 2.70 and 2.90 and methods of placing which do not involve high frequency vibration. When sharp, angular manufactured sands, or extremely coarsely graded sands are used, the relative amount of fine aggregate should be increased. For finer sands the relative amount of fine aggregate should be decreased. In general, the least amount of sand which will insure concrete of the required workability for the placing conditions involved should always be compensated for by changing the weight of coarse aggregate in the opposite direction by a corresponding amount.

Table 2-3 (I): Requirements of concrete composition

Class of concrete	Compressive strength at 28 days (in Kg/cm ²) Cube	Minimum cement content (Kg)	Coarse aggregate size	Max. water content (Liter per Bag)	Consistency range in slump (mm)	
					vibrated	non vibrated
A	250	375	¾ inch or 1 inch- No. 4 as required by the Engineer	27	50- 100	75- 125
B	200	350	Ditto	27	50- 100	33- 125
C	150	250	2 inch- No. 4	30	25- 50	50- 75

Table 2-3 (II): Requirements of concrete composition- Continue

Class of concrete	Cylinder compressive strength at 28 days (kg/ cm ²)	Approximate Weight (Saturated Surface-Dry) of Fine and Coarse Aggregate per Sack (50Kgs) of Cement			
		Rounded coarse aggregate		Angular coarse aggregate	
		Fine (Kg)	Coarse (Kg)	Fine (Kg)	Coarse (Kg)
A	250	40	170	95	150
B	210	95	180	100	160
C	140	140	370	160	340

Table 2-3 (II) is given for indicative purposes and is not binding.

The total sodium chloride content of any materials used for making concrete shall be less than:

- For mass concrete..... 1.5 percent
- For reinforced concrete..... 0.7 percent

Expressed as a percentage, by weight of the cement.

In calculations made under the provisions of this clause, any chloride, other than sodium chloride in the materials shall be converted to the equivalent of sodium chloride and be added to the amount of sodium chloride. The sulphate content shall not exceed 0.03 percent by weight of the cement.

2.5 PROPORTIONS

2.5.1 General

After the materials provided by the Contractor have been accepted for the works, the proportions and equivalent batch weights shall be determined which will produce concrete having not less than the strength required.

2.5.2 Trial Mixes

The actual proportions shall be determined on the basis trial mixes made by the Contractor and conducted with the content being determined by means of yield test in accordance with American Society for Testing Material (ASTM) Designation (C-138). The proportions will be such as to required (within a tolerance of plus or minus one (1) percent, the cement content shown in Table I as the minimum cement content, provided, however, that if the materials supplied by the Contractor are of such a nature or are so graded that proportions based on the minimum cement content cannot be used without exceeding the maximum allowable water content specified in Table I, the proportions will be adjusted so as to require the least amount of cement which will produce concrete

of the required plasticity and workability without exceeding such maximum allowable water content. No additional compensation will be made for the increase in quantity of cement required.

2.5.3 Contents

The mixes required will be designated in kilograms of fine and coarse aggregate exclusive of free water, per sack (50 Kilograms) of cement and in liters of total mixing water per sack of cement on the basis of the required amount of cement per cubic meter of concrete.

2.5.4 Batch Weights

Since the proportions are designated in terms of aggregate in surface-dry condition, the equivalent batch weights to be used in the work shall be corrected periodically to take into account the actual moisture content of the aggregates at the time of use.

2.6 CONCRETE COMPRESSION AND SLUMP TESTS

2.6.1 Cubical Test

The Compression Strength of Concrete shall be obtained according to cubical tests locally done. Test cubes made in the field shall have a dimension of 15cm, At least 3 separate batches of concrete shall be made for trial and these shall be tested for compliance with the requirements of the table below, at least 3 test cubes being made from each batch of concrete. Once a mix is approved no substantial change in the materials or proportions of materials being used shall be made without the approval of the director of works who may then require further trial mixes to be produced. The compressive strength of the concrete will be taken as the arithmetic mean of the strength of all the cubes tested.

The following table 2-4 will be used to compare test results:

Table 2-4: Compressive Strength results of samples of concrete at 28 days. (Mixed by Weight)

Kind of Concrete	Mean value At 28 days Kg / cm ²	Minimum Individual Value at 28 days Kg / cm ²	Mean value At 28 days Kg / cm ²	Minimum Individual Value at 28 days Kg / cm ²
	In case of 3-4 samples taken		In case of 5 samples or more	
B - 150	185	130	175	130
B - 200	240	170	230	170
B - 250	300	215	290	215
B - 300	360	255	345	255
B - 350	420	300	405	300

Test at 7 days must not be less than 75% of the required strength at 28 days

2.6.2 Slump Tests

Slump tests shall be carried out periodically to ensure the appropriate water cement ratio in accordance with the Standard Method of Test of Slump of Portland Cement Concrete of the ASTM Designation: C-143.

2.6.3 Test of Hardened Concrete in the Structure

Where the results of specimens indicate that the concrete does not meet specification requirements,

core boring tests conforming to the current issue of ASTM Designation: C-42 shall be performed, as directed by the Engineer, all at the Contractor's expense.

1. Hardened concrete is identical to specifications if the results of specimens test follow the conditions:
 - At least the average compressive strength of samples testing coincides the required design strength for the concrete.
 - No compressive strength of any of the sample specimens deviates from the required design strength for the concrete by (85%).
 - Cubes are standard size (150 × 150 × 150) mm and age (28) days mainly to the requirements of comparing strength. The nominal compressive strength is the minimum value of all the values of the testing samples, which does not allow the existence of values lower than more than (5) percent of the number of sample tests.
 - The contractor to submit to the supervisor written reports from an authorized laboratory for all of the tests carried out according to specifications and within period of not more than (24) hours of the implementation of the testing.
2. If the cube tests fail to pass the above; Core Specimens must be carried out at (3) specimens for each sample of hardened concrete which had not achieved the conditions of the sub-item mentioned above. Note that taking the specimens, water treatment and testing are in accordance with the requirements of American Standard (ASTM -C 42), this is coincided to the concrete specifications if the test results match following conditions:
 - At least the average compressive strength of the specimens of a sample is (85%) of the strength provided by the design.
 - At least the compressive strength of an individual specimen from a sample is (75%) of the strength provided by the design.
3. If test results fail to pass the condition stated in item (B) of this section, found not conform to these specifications, and must then be completely removed from the site at the expense of the contractor, as the same contractor bears full responsibility for any damage that might be caused to the sound elements as a result of the demolition and removal.
4. As exception to what is stated in paragraph (C) of this section, for the slabs and beams only, if the average value of compressive strength of the samples equivalent to the standard cubes (150 * 150 * 150) mm is not less than (150Kg/cm²); loading test might be carried out only upon the client request and at the contractor's expense to ensure the ability of the concrete elements to bear loads according to engineer and the designer. If the elements pass the load test, then the slabs and beams are considered structurally accepted.
5. Loading Test
 - Load test must be carried out at the site for the slabs and beams of reinforced concrete that are under the age of (56) days by authorized and experienced laboratory in that field. The loads must be equivalent to that part of the actual dead loads and shall be placed on the slabs and beams prior to loading the total loads by (48) hours and remain until the end of the test.
 - The slabs and beams must be loaded by a total of (0.85) multiplied by (1.4 Dead Load + 1.7 Live Load) Less Dead Load actually performing (48) hours before. Special devices should be placed at the bottom of slabs and beams to measure deflection. These devices should be installed on fixed frames to ensure the stability of these devices, and the preliminary readings to be taken prior to process of loading. The loads must be placed gradually and systematically for (24) hours, without causing any vibrations or shocks and batches of not less than (4) equal installments, and then taking the readings , which identifies the

maximum deflection; that is the difference between this reading and reading pre-loading. Then the loads are lifted and left unloaded for two (24) hours, the readings are taken for the final deflection which determines the value of self-retrieval as the difference between this reading, and reading pre-lift.

6. Passing the test

- The structural elements could succeed in passing the test, if not exceed the maximum deflection (D) in mm as per the formula:

$$D = (50 L^2) / h$$

Where:

L = Span loaded in meters of the following values: the distance between the centers of supports or clear span loaded plus the height of the structural element which is smaller.

h = height of the structural element (mm)

- The slabs and beams fail to pass the test if wide cracks appear or signs of failure during the test, or if they do not achieve the value of deflection (D).

2.7 MEASUREMENT OF MATERIALS

Materials shall be measured by weight, except as otherwise specified or where other methods are specifically authorized by the Engineer. The apparatus provided for weighing the aggregates and cement shall be suitably designed and constructed for this purpose. Each size of an aggregate and the cement shall be weighed separately. The accuracy of all weighing devices shall be such that successive quantities can be measured to within 1% of the desired amount. Cement in standard packages (sack) need not be weighed. The mixing water shall be measured by a measuring device susceptible of control accurate to plus or minus half percent of the capacity of the tank but not exceeding 2 liters. All measuring devices shall be subject to the Engineer's approval.

Where volumetric measurements are exceptionally authorized by the Engineer for projects where the amount of concrete is small, the weight proportions shall be converted to equivalent volumetric proportions. In such cases, suitable allowance shall be made for variations in the moisture condition of the aggregates, including the bulking effect in the fine aggregate.

2.8 MIXING OF CONCRETE

2.8.1 General

Unless otherwise authorized by the Engineer, concrete shall be machine mixed.

The mixing of concrete or mortar shall not be permitted when the temperature is above 40 C or when the temperature is below 5 C.

2.8.2 Mixing on Site

Concrete shall be thoroughly mixed in a batch mixer conforming to the requirements of B.S. 1305 Batch type concrete mixers which will ensure a uniform distribution of the materials throughout the mass.

The mixer shall be equipped with adequate storage and a device for accurately measuring and

automatically controlling the amount of water used on each batch. Preferably mechanical means shall be provided for recording the number of revolutions for each batch and automatically preventing the discharge of the mixer until the materials have been mixed within the specified minimum time.

The entire contents of the mixer shall be removed from the drum before materials for a succeeding batch are placed therein.

All concrete shall be mixed for a period of not less than 1 ½ minutes after all materials, including water, are in the mixer. During the period of the mixing the mixer shall operate at the speed for which it has been designed, but this speed shall be not less than 14 nor more than 20 revolutions per minute.

The first batch of concrete material placed in the mixer shall contain sufficient excess of cement, sand and water to coat the inside of the drum without reducing the required mortar content of the mix. Upon the cessation of mixing for a considerable period, the mixer shall be thoroughly cleaned.

2.8.3 Truck 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 in accordance with Section C.7 and charged into the drum at the proportioning plant.

Except as subsequently provided, the truck mixer shall be equipped with a tank for carrying mixing water. Only the prescribed amount of water shall be placed in the tank unless the tank is equipped with a device by which the quantity of water added can be readily verified. Truck mixers may be required to be provided with means by which the mixing time can be readily verified by the Engineer.

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 50 revolutions after all ingredients including the water, are in the drum. The speed shall not be less than 4 r.p.m., nor more than a speed resulting in a peripheral velocity of the drum of 70 meters per minute.

Nor more than 100 revolutions of mixing shall be at speed in excess of 6 r.p.m. Mixing shall begin within 30 minutes after the cement has been added either to the water or aggregate. When cement is charged into a mixer drum containing water or surface-wet aggregate and when the temperature is above (33 C) is used this limit shall be reduced to 1245 minutes; the limitation on time between the introduction of the cement to the aggregates and the beginning of the mixing may be waived when, in the judgment of the Engineer, the aggregates are sufficiently free from moisture, so that there will be no harmful effects on the cement.

2.8.4 Partial mixing at the Central Plant

When a truck mixer provided with adequate mixing blades is used for transpiration, the mixing time at the mixing plant may be reduced to 30 seconds and the mixing completed in the truck mixer. The mixing time in the truck mixer shall be as specified under the Section C.8.3 for truck mixing.

2.8.5 Plant Mix

Mixing at a central plant shall conform to the requirements for mixing at the Site and shall conform to

the applicable requirements of the Standard Specification for Ready-Mixed Concrete of ASTM Designation: C-94.

2.8.6 Time of Hauling and Placing Concrete

If the distance from the mixing plant to the construction Site is so great that between the time of mixing and pouring the concrete, the temperature is below 40 C and the traveling time is more than 30 minutes, truck mixers must be employed.

When truck mixers are used, concrete shall be discharged and placed in its final position in the forms within thirty (30) minutes after water is first added to the mix.

2.8.7 Delivery

The rate of 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 20 minutes. The methods of delivering and handling the concrete shall be such as will facilitate placing with the minimum of re-handling and without damage to the structure of the concrete.

2.8.8 Re-tempering

The concrete shall be mixed only in such quantities as are required for immediate use and any concrete which has developed initial setting shall not be used. Concrete which has partially hardened shall not be re-tempered or remixed.

2.9 HANDLING AND PLACING CONCRETE

2.9.1 General

Prior to pouring concrete in any structure, the Contractor shall secure a written order to commence from the Engineer. In preparation for the placing of concrete all sawdust, chips, and other construction debris and extraneous matters shall be removed from the interior of forms, struts, stays and braces, serving temporarily to hold the forms in correct shape and alignment, pending the placing of concrete placing has reached an elevation rendering their service unnecessary. These temporary members shall be entirely removed from the forms and not buried in the 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 from the mixer to the forms shall not be permitted unless the authorization in writing of the Engineer is obtained. In case an interior quality of concrete is produced by the use of such conveyers, the Engineer may order discontinuance of their use and the substitution of a satisfactory method of placing. Open troughs and chutes shall be of metal lined and shall be of rounded cross section to avoid the accumulation of concrete in corners. The chutes shall be equipped with baffles or be in short lengths that reverse the direction of movement. The slope shall be steep enough (1 vertical to 2 or 2 ½ horizontal) to permit flow requiring a slump greater than specified or required for placement.

All chutes, troughs and pipes shall be kept clean and free from coating of hardened concrete by thoroughly flushing with water after each run. Water used for flushing shall be discharged clear of the structure. When placing operations would involve dropping the concrete more than 1.50 meter, it shall be deposited through sheet metal or other approved pipes. As far as practicable, the pipes shall be kept full of concrete during placing and their lower ends shall be kept buried in the newly

placed concrete. After initial setting of concrete, the forms shall not be jarred and no strain shall be placed on the ends of reinforcement bars which project.

2.9.2 Hot Weather Concreting

The temperature of concrete when placed shall not exceed 27 °C when the relative humidity is 50 percent or less and shall not exceed 32 ° C for values of relative humidity between 50 percent and 70 percent, the max temperature of concrete shall be found by interpolation.

In lieu of above, the temperature of concrete when placed shall not exceed 32 ° C, regardless of the relative humidity.

The Contractor shall comply with the above requirements by the following procedures:-

- Cooling the mixing water and/or replacing 50% of the mixing water by crushed ice. When crushed ice is used it shall be stored at a temperature that will prevent formation of lumps. The ice shall be completely melted by the time mixing is completed.
- Shading aggregate stockpiles and/or keeping moist by sprinkling then with water.
- Cement shall not be used if its temperature exceeds 77 °C.
- Painting the mixer drum white and spraying it with cool water or shading the mixer from direct sunrays.
- Maintaining the mixing time and delivery time to the minimum acceptable.
- Sprinkling of forms sub-grade and reinforcement with cool water prior to placement of concrete.

Water reducing and retarding admixture shall be used in all concrete work when the temperature of concrete exceeds 27 ° C. The water cement ratio inclusive of free surface moisture on aggregates and any admixtures shall be kept to a minimum.

2.9.3 Vibrating Concrete

Concrete, during and immediately after depositing, shall be thoroughly compacted. The compaction shall be done by mechanical vibration subject to the following provisions:

- Vibration shall be internal unless special authorization of other methods is given by the Engineer or as provided herein.
- Vibration shall be of a type and design approved by the Engineer. They shall be capable of transmitting vibration to the concrete at frequencies of not less than 4500 impulses per minute.
- The intensity of vibration shall be such as to visibly affect mass concrete of 25mm slump.
- Contractor shall provide a sufficient number of the vibrators to properly compact each batch immediately after it is placed in the forms.
- Vibration 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.
- Vibration shall be applied only by experienced operators under close supervision, at the point of deposit and in the area of freshly deposited concrete. The vibrators shall be inserted

and withdrawn out of the concrete slowly. The vibration shall be of sufficient duration and intensity to thoroughly compact the concrete, but shall not be continued so as to cause segregation. Vibration shall not be continued at any point to the extent that localized areas of grout are formed.

- Application of vibration 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 or through the reinforcement to sections or layers of concrete which have hardened to the degree that the concrete ceases to be plastic under vibrations. 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 in the forms.
- Vibrator shall be supplement by such spading as it necessary to ensure smooth surface and dense concrete along form surfaces and in corners and locations impossible to reach with the vibrators.
- The use of implements such as compressors which are likely to disturb or disarrange reinforcement or formwork shall not be permitted.

Concrete shall be placed in horizontal layers not more than 300mm thick 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 batch has taken initial set to prevent injury to the green concrete and avoid surfaces of separation between the batches. Each layer shall be compacted so as to avoid the formation of a construction joint with preceding layer which has taken initial set.

When the placing of concrete is temporarily discontinued, the concrete after becoming firm enough to retain its form, shall be cleaned of laitance and other objectionable material to a sufficient depth to expose sound concrete. To avoid visible points as far as possible upon exposed faces, the top surface of the concrete adjacent to the forms shall be smoothed with a trowel.

Immediately following an approved discontinuance of placing concrete all accumulations of mortar splashed upon the reinforcement bars and the surfaces of forms shall be removed. Dried mortar chips and dust shall not be puddle into the unset concrete. If the accumulations are not removed prior to the concrete becoming set, care shall be exercised not to injure or break the concrete steel bond at and near the surface of the concrete while cleaning the reinforcement bars.

2.9.4 Joints

Expansion joints shall be formed in the positions indicated and to the details shown on the Drawings or otherwise ordered by the Engineer. The expansion joints shall be filled with bitumen impregnated fiberboard to its full depth and width. The filling will be permitted to be used as permanent formwork only for the second casting. Where the fiberboard is exposed, it shall be cut back for a depth of at least 1cm. from the chamfered edges, filled and pointed with a resilient liquid poly sulphide polymer sealant. Whenever the placing of the concrete is discontinued other than at the expansion faces, this discontinuity shall form a construction joint. Construction joints are to be made only along a horizontal or vertical plane except that in the case of inclined or curved members they shall be at right angles to the principal axis. Care shall be taken to prevent offsetting of the joint and to ensure water tightness. The joints shall in every way satisfy the requirements of the Engineer, and be in accordance with the Drawings.

Unless otherwise shown on the Drawings, construction joints will not be allowed in the supported portion slabs, beams and beam like members. At construction joints the laminate film and porous

layer of the already set concrete shall be removed and the surface keyed by hacking and then wire-brushed and thoroughly cleaned. Immediately before adding the new concrete, the surface is to be thoroughly wetted and a 1-cm thick coating of a fresh cement/sand mortar (having the same proportion of cement/sand as concrete in the mix) applied to the surface. The new concrete is then to be well compacted into the old.

The number of construction joints should be kept as few as possible consistent with reasonable precautions against shrinkage. Concreting should be carried out continuously up to construction joints.

Where it is necessary to introduce construction joints, careful consideration should be given to their exact location, which should be indicated on the drawings.

2.10 PRECAST HOLLOW CONCRETE BLOCKS [HOURDIS] FOR RIBBED SLABS:

2.10.1 Material and Manufacture

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

Pre-cast hollow concrete blocks (hourdis) for a ribbed slab shall be manufactured in approved vibrated, machine.

If for any reason the strength requirement is not achieved, cement shall be increased at the Contractor's own expense. The blocks shall be cured for twelve (12) consecutive days and shall be at least twenty-one (21) days old before incorporation in the Works. The blocks shall be of an approved pattern of withstanding a compressive force applied at the ends of 30 kgs/cm² based on the gross sectional area of the block obtained without deducting voids.

The blocks shall be hard, sound, durable, sharp, clean with well defined arises, free from cracks and flaws or other defects and of the dimensions shown on the Structural Drawings. The blocks shall be obtained from an approved local factory.

2.10.2 Workmanship

Pre-cast hollow concrete blocks (hourdis) shall be laid exactly in a line with the cells on the long dimensions.

Close edge blocks shall be used at the end; the dimensions of the ribs and size of reinforcing bars shall be exactly according to the Structural Drawings. In narrow width specially made half blocks shall be used and full block shall not be used along their length (with the calls along the long dimensions of the rib.)

The blocks are to be laid on adequate forms. All blocks shall be cleaned and thoroughly wetted with clean water before the concrete is poured and labourers shall not be allowed to walk on them. Any block found to be defective or damaged during concreting operations shall be removed and replaced before pouring the concrete, all at the contractor's expense.

2.11 FORMWORK

2.11.1 General

The Contractor shall be responsible for the design and stability of the formwork. The contractor

shall submit a full program of work indicating the various phases for the erection and removal of forms and the manner in which he intends to execute all concrete works.

2.11.2 Material

All forms shall be of wrought lumber and shall be built mortar tight and of sufficient rigidity to prevent distortion due to the pressure of the concrete and other loads incident to the construction operations. Forms shall be constructed and maintained so as to prevent warping and the opening of joints due to shrinkage of the lumber.

The forms shall be substantial and unyielding and shall be so designed that the finished concrete will conform to the proper dimensions and contours. The Contractor shall take into consideration the effect of vibration on the formwork, and shall be responsible for any damage or default resulting thereof.

2.11.3 Workmanship

Forms shall be inspected by the Engineer prior to installation of reinforcement

The number of spacing of the form struts and braces shall be such that the forms will be braced rigidly and uniformly lock joints between form sections shall be free from play or movement.

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

Metal tie rods or anchorages within the forms shall be so constructed as to permit their removal to a depth of at least 40mm from the face within injury to the concrete. In case ordinary wire ties are permitted, all wires, upon removal of the forms, shall be cut back at least 10mm.

From the face of the concrete with chisels or nippers for green concrete, nippers are necessary. All fittings for metal ties shall be of such design that the cavities produced upon their removal are the smallest possible.

The cavities shall be filled with non-shrinkage material mortar and the surface left sound, smooth, even and uniform in colour.

All forms shall be treated with special approved oil and saturated with water immediately before placing the concrete. For members with exposed faces, the forms shall be treated with approval material to prevent the adherence of concrete.

Any material which will adhere to or discolour the concrete shall not be used.

The contractor shall provide means for accurately measuring the settlement of the forms during placement of the concrete and shall make all necessary corrections as directed by the Engineer way release the contractor of his responsibility for the correctness of these schedules.

All reinforcement shall be placed strictly in accordance with the drawings and as instructed in writing by the Engineer. Nothing shall be allowed to interfere with the required disposition of the reinforcement, and the Contractor shall ensure that all parts of reinforcement are placed correctly in position and are temporarily fixed where necessary to prevent displacement before or during the process of tamping and ramming the concrete in place. The ties, links or stirrups connecting the bars shall be taut so that the bars are properly braced the inside of their curved part shall be in actual contact with the bars, around which they are intended to fit.

Placed correctly in position and are temporarily fixed where necessary to prevent displacement before or during the process of tamping and ramming the concrete in place.

The ties, links or stirrups connecting the bars shall be taut so that the bars are properly braced the inside of their curved part shall be in actual contact with the bars, around which they are intended to fit.

2.11.4 Removal of Form-work

In the determining of the time for removal of forms, 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. In general, the forms of any positions of the structure shall not be removed until the concrete is strong enough to prevent injury to the concrete when the forms are removed. Unless otherwise directed by the Engineer forms shall remain in place for the following specified period of time:

- Centering under beams : 21 days
- Floor slabs : 21 days
- Walls, columns, sides of beams and other vertically formed surfaces : 3 days

Method 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 the written approval of the Engineer. 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.

Centers shall be gradually and uniformly lowered in such a manner as to avoid injurious stresses in any part of the structure.

The Contractor shall include in his prices for any formwork which may have to be left in position due to the impossibility of removal of same.

2.12 REINFORCEMENT

2.12.1 General

The contractor shall prepare for his own use bar bending schedules from the information given on the drawings and in these specifications. These schedules shall be submitted to the Engineer for approval which shall in no way release the contractor of his responsibility for the correctness of these schedules.

All reinforcement shall be placed strictly in accordance with the drawings and as instructed in writing by the Engineer. Nothing shall be allowed to interfere with the required disposition of the reinforcement, and the contractor shall ensure that all parts of reinforcement are placed correctly in position and are temporarily fixed where necessary to prevent displacement before or during the process of tamping and ramming the concrete in place. The ties, links or stirrups connecting the bars shall be taut so that the bars are properly braced the inside of their curved part shall be in actual contact with the bars, around which they are intended to fit. Placed correctly in position and are temporarily fixed where necessary to prevent displacement before or during the process of tamping and ramming the concrete in place.

The ties, links or stirrups connecting the bars shall be taut so that the bars are properly braced the inside of their curved part shall be in actual contact with the bars, around which they are intended to fit.

2.12.2 Type and Quality of Steel Reinforcement

1. Hot-Rolled Steel Plain Rods and Bars

Hot rolled steel plain rods and bars shall conform to the strength requirements and minimum elongation of the Standard Specification for Deformed Billet-Steel Bars of Grade 40 with minimum yield strength 2400Kg/cms (35000 psi) for concrete Reinforcement of ASTM Designation (A-615) or equivalent.

2. Deformed Steel Rod and Bars

Deformed steel and bars shall conform to the requirements of the Standard Specification for Deformed Billet-Steel Bars of grade 60 with minimum yield strength 4200 kg/cm² (60000 psi) for concrete reinforcement of ASTM Designation (A-615) or equivalent.

2.12.3 Wire

Wire for bending reinforcement bars shall be of soft black annealed mild steel wire. The diameter of the Wire shall not be less than 16 S.W.G. (1.6mm) and the binding shall be twisted tight with proper pliers. The free ends of the binding wire shall be bent inwards.

2.12.4 Order Lists

Before ordering material, all order lists and bending diagrams detailed in accordance with the latest revision of AGI Building Code shall be furnished by the contractor for the approval of the Engineer, and no material shall be ordered until such lists and steel bending diagrams have been approved. The approval of order lists and bending diagrams by the Engineer shall in no way relieve the contractor of his responsibility for the correctness of such lists and diagrams. Any expenses incurred to the revision of material furnished in accordance with such lists and diagrams to make and comply with the design drawings including cut and waste shall be borne by the contractor.

2.12.5 Protection of Material

Steel reinforcement shall be protected at all times from injury. When placed in the work, it shall be free from dirt, detrimental scale, paint, oil, loose, rust, grease or other foreign substances.

2.12.6 Fabrication

Bar reinforcement shall be bent to the shapes shown on the Drawings and Steel Bending (Diagrams), bending dimensions and scheduling of bars for the reinforcement of concrete. All bars shall be bent cold, unless otherwise permitted by the Engineer. No bars partially embedded in concrete shall be bent except as shown on the plans or specifically permitted by the Engineer.

2.12.7 Placing and Fastening

All steel reinforcement shall be accurately placed in the position shown on the drawings and firmly held during the placing and setting of concrete. Bars shall be tied at all intersections except where spacing 300mm in each direction, in which case alternate intersections shall be tied.

Distance from the forms shall be maintained by means of stays, blocks ties, hangers, or other approved supports. Blocks for holding reinforcement from contact with the forms shall be pre-cast mortar blocks of approved shapes and dimensions or approved metal or plastic chairs. Metal chairs which are in contact with the exterior surface of the concrete shall be galvanized. Layers of bars shall be separated by pre-cast mortar blocks or by other equally suitable devices. The use of pebbles, pieces of broken stone or brick, metal pipe and wooden blocks shall not be permitted.

Reinforcement in any member shall be placed and then inspected and approved by the Engineer before the placing of concrete begins. Concrete placed in violation of this provision may be rejected and its removal is required.

2.12.8 Splicing

All reinforcement shall be furnished in the full lengths indicated on the drawings. Splicing bars, except where shown on the drawing, will not be permitted without the written approval of the Engineer. Splices shall be staggered as far as possible.

Additional splices, other than those shown on the drawings; and allowed by the Engineer, shall be at the contractor's own expense.

The cost of all supports for holding reinforcement bars shall be borne by the Contractor.

2.13 CURING AND PROTECTION

2.13.1 Water Curing

All concrete shall be cured for a period of time required to obtain the full-specified strength but not less than seven (7) consecutive days. Unformed surfaces shall be covered with sand burlap, or other approved fabric mats kept continually wet. If the forms are removed before the end of the curing period, curing shall be continued as on the unformed surfaces. When burlap, sand or other approved fabric materials are used, they shall not cause any undesirable finish such as rough surface and discoloring where exposed to light. Unhardened concrete shall be protected from heavy rains or flowing mechanical

injury and the Contractor shall submit for the Engineer's approval his construction procedure which is designed to avoid such an eventually. No fire or excessive heat shall be permitted near or in direct contact with concrete at any time. Water for curing shall conform to Section 2.3.6.

2.13.2 Curing with Curing Media

Curing medium shall meet all requirements of the specifications for Liquid Membrane-Forming Compounds for Curing Concrete of ASTM Designation: C-309 and test for water retention by concrete curing materials of ASTM Designation: C-156.

The compound shall be applied to the concrete surface by means of a sprayer, roller or lamb's wool applicator and shall be sprayed on. Ample time shall be allowed for the concrete surface to harden and to prevent any damage. The compound shall give a drying time not to exceed thirty minutes, and shall be applied undiluted directly from the manufacturer's labeled container in accordance with the manufacturer's directions and to the satisfaction of the Engineer.

The compound shall be completely compatible with adhesives, joint sealants and cement grout.

2.13.3 Payment

No separate payment shall be made for curing with water or with curing media. The cost of such curing shall be deemed to be included in the Unit Prices of "CONCRETE WORK".

2.14 CONCRETE [FAIR FACE] EXPOSED SURFACES

2.14.1 Formwork

Formwork for exposed concrete surface shall conform to the applicable requirements of Section C 14, in addition to those Specifications.

All concrete surfaces that are to be left exposed to view as a finished surface except for pre-cast concrete units, shall be produced by vertical metal shuttering.

The quantity of the surface of concrete exposed to view shall be consistent throughout the project and the following methods shall be adopted to obtain the required finish.

Metal forms of an approved type for pre-cast units

The Contractor may submit alternative proposals for the Engineer's approval if he so desires.

The Contractor is to submit to the Engineer for his approval shuttering details and sequence of operation relating to fair face concrete work. Sample panels shall be constructed for all their face concrete finishes and following the Engineer's approval the panels will remain on site and constitute a standard which must be maintained throughout the duration of the Contract.

2.14.2 Coating Forms with Mineral Oil

In addition to the above forms or linings, the forms shall be coated before placing reinforcement with an approved colourless mineral oil free of kerosene.

All surplus oil on form surfaces and any oil on reinforcing steel shall be removed.

2.14.3 Samples and Workmanship

The Contractor shall submit for approval a sample panel not less than 600x1200mm to demonstrate the quantity of the exposed concrete produced by forms at his own expense.

The quantity of the finished work shall be measured against the quality of the approved sample panel and the work of inferior quality shall be repaired or replaced as directed by the Engineer without any additional cost.

The quality of the finished surfaces shall be uniform in colour and consistency, whether in colour or in texture, in any of the finished surfaces, the Engineer may order the repair or the demolition of the portion of concrete work and the reconstruction of same at the expense of the contractor and the contractor shall have no right to claim for any expenses or time delay incurred.

Alternatively the Engineer may order the contractor to plaster all exposed surfaces and bush-hammer the entire area of, concrete in the project so as to render all exposed surfaces of concrete consistent throughout the project at the contractor's own expense.

2.15 MONOLITHIC SMOOTH FINISH SURFACES

All concrete surfaces which are not in acceptance condition and which are required to be surface-finished as designated herein, shall be rubbed to a smooth and uniform texture with a carborundum brick and clear water as soon as the forms are removed and the concrete is ready to hone. The loose material formed on the surface shall be removed as soon as it dries by rubbing the surface with burlap or other approval material. A cement wash shall not be used.

Concrete surface shall be free from honeycombing, air holes, fins and projections arising from

defective mixings, placing or formwork. When the formwork has been stuck off, the surface of concrete shall be left untouched until inspected by the Engineer. Any defective concrete work shall at the discretion of the Engineer be demolished completely and rebuilt or cut out and made good with concrete of the same proportions as the original. Such rectifications shall be to the satisfaction of the Engineer and at the Contractor's own expense.

3 -BLOCK WORKS

3.1 SCOPE

These specifications cover the supply of materials, manufacture and workmanship of concrete blocks or Glass blocks intended to be used for the construction of block wall, partitions, facings, etc., required for the project in accordance with the Drawings, Bills of Quantities and as directed in writing by Engineer.

3.2 CONCRETE BLOCKS

3.2.1 Materials

Cement

Cement for solid or hollow blocks and mortar shall be Ordinary Portland Cement ASTM Designation C 150-74 and white cement ASTM: C 91-71.

Aggregates

Aggregate for solid and hollow concrete blocks and mortar shall conform to the requirements for fine aggregates in the following Table 3-1:

Table 3-1: Aggregate Percentage Passing for Blocks

Sizes BS sieve No.	Sieve Opening (inch)	Sieve opening (mm)	% Passing
1/8	0.125	3.00	95-100
7	0.095	2.40	80-100
14	0.047	1.20	60-100
25	0.024	0.60	30-100
52	0.012	0.30	0.5- 100
100	0.006	0.15	0.0- 0.1

Note: The above figures represent the limits of percentages (by weight) passing sieves of the sizes mentioned.

Water

Water to be used in block work shall conform to the requirements specified for water in the "Concrete Work" Section.

Lime shall be non-hydraulic lime compiling in all respects with B.S. 890, and shall be prepared in accordance with the appropriate requirements of British Standard Code of Practice 121: Part 1: 1973, latest revision.

The contractor must satisfy himself by analysis or otherwise that the ground lime is not adulterated or air-slaked.

Factory-produced, dry, hydrated, non-hydraulic or semi-hydraulic lime ready for use, shall be mixed with sand and made into coarse mix or be soaked to putty by mixing with water and allowing to stand not less than (16) sixteen hours before use.

The lump or ground non-hydraulic or quick-lime shall be slaked, run to putty and matured for not less than two (2) weeks.

1. Aggregate shall be so sized, graded, proportioned and thoroughly mixed in a batch 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 250kg per cubic meter of concrete.
2. Pre-cast concrete blocks shall be manufactured in approved vibrated machines. If for any reason the strength requirements are not achieved, the cement shall be increased at the contractor's own expense. The water used in the mix shall be clean and of a sufficient quantity to allow complete hydration of the cement without providing an excess when molding.
3. Concrete blocks shall be hard, sound, durable, sharp, rectangular shape, clean with well define arises free from racks and flaws or other defects. Concrete blocks shall be either obtained from an approved local factory.
4. Blocks manufactured on the site shall be cured in the shade by being kept thoroughly moist with water applied by sprinklers or other approved means for a period of at least seven (7) days. The blocks shall be stocked on a clean and level platform free from earth or other impurities during the curing process, and shall be stocked in honey-comb fashion after curing. The blocks shall not be used prior to one (1) month after the date of manufacture.
5. Concrete blocks (solid or hollow) shall be of the following dimensions:-

Height = 200 mm + 1 % Tolerance
 Length = 400 mm + 1 % Tolerance
 Width = As required + 1 % Tolerance
 Web thickness = not less than 20 mm for block (40*20*10)/ or
 not less than 25 mm for block (40*20*15)/ or
 not less than 30 mm for block (40*20*20)

The nominal width of blocks shall be as indicated on the Drawings and as directed by the Engineer.

6. Hollow concrete blocks shall comply with the following requirements: -
Compressive Strength at Twenty Eight (28) Days Over Gross-Sectional Area: -

39

60 kgs/cm² average of 12 blocks
 50 kgs/cm² minimum for any block

Hollow Blocks:

35 kgs/cm² average of 12 blocks
 30 kgs/cm² minimum for any block

7. Water Absorption

20% or less of dry weight

8. The contractor shall supply minimum 12 blocks from each supplying quantity up to 20,000 blocks or in case of change the manufacturer for testing the blocks before starting the masonry works. The all needed tests shall be on the contractor expenses.

9. The design of the cavities and webs of the hollow concrete blocks shall be submitted to the Engineer prior to manufacture. The thickness of the face shell and of the membrane of solid portions shall be nowhere less than 20mm. The combined thickness of the solid portions shall be not less than one fourth (1/4) of the width and length of the block respectively.

10. Concrete blocks for ribbed slabs shall be of the following dimensions:-

Length L (mm)	Height H (mm)	Width B (mm)	Minimum web thickness (mm)	
			For 3 eyes	For 2 eyes
400 Or 500	140	200- 300	20	----
	150	200- 300	20	22
	170	200- 300	20	22
	200	200- 300	20	22
400	250	200	22	22
500	350	200	25	----
+3 mm	+1 mm	+5 mm for one consignment	----	----

The nominal width of blocks shall be as indicated on the Drawings and as directed by the Engineer.

11. Weight of concrete blocks for ribbed slabs are specified as follows:-

Length L (mm)	Height H (mm)	Width B (mm)	Max Specific Weight (kg/m ³)	
			For 3 eyes	For 2 eyes
400 Or 500	140	200- 300	1100	---
	150	200- 300	1100	---
	170	200- 300	1000	850
	200	200- 300	1000	850
400	250	200	1000	850
500	350	200	950	---

12. blocks for ribbed slabs shall comply with the following requirements: -

Flexural Strength at Twenty Eight (28) Days Over Gross-Sectional Area: -

P (N) =2B minimum average of 6 blocks

P (N) =1.8B minimum for any block

Which;

P is the concentrated flexural load (N)

B is the width of the block (mm)

3.2.3 Mortar

1. Mortar shall be prepared in the following proportions with the addition of the minimum quantity of clean water for workability:
2. Cement and sand mortar (1:3) mix, shall be composed of one part cement to three parts of sand by volume.
3. Hydrated lime up to 1/4 (one quarter) by volume of the dry cement may be added for bedding blocks, upon the approval of the Engineer, to improve workability without appreciably reducing the strength.
4. The ingredients for cement and sand shall be measured in the proper clean gauge boxes and the mixing shall be carried out by means of an approved mechanical batch mixer.
5. In the cast of cement-lime mortar, the sand and lime shall be mixed first and the cement added. It shall be assumed that the lime has not increased the bulk of the sand.
6. 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 Engineer, be immediately removed from the site.

3.2.4 Workmanship

1. Block test results and approval from the engineer must be taken before starting the block work.
2. All block work shall be set out and built to the respective dimensions, thickness and heights shown on the drawings and/or instructed in writing by the engineer.
3. All walls and partitions, where shown on the drawings without indicating the type of the block to be used, shall be built in hollow concrete blocks, unless otherwise directed in writing by the engineer.
4. The blocks shall be well buttered with mortar before being laid and all joints shall be in uniform manner and shall not exceed soaked before being used and the tops of wall left off shall be wetted before work is recommenced. All blocks shall, no one portion being raised more than 1.20 m above in one day, and wall of partition necessarily left at different levels, must be racked back. All perpendiculars, quoins, internal and external angles, etc. properly bonded together and leveled round. All block work shall be plumbed vertically.
5. The surface of the walls and partitions prepared for plastering shall have the joints raked out 50 mm into the face of the wall to form key for the plaster.
 - 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.
 -

The accepted verticality tolerance must be within the following:

For every 3m height	+ 6 mm Tolerance
For every floor up to 6m height	+ 11 mm Tolerance
For 12 m height and more	+13 mm Tolerance
For boundary wall, expansion joint and decoration	+ 6 mm Tolerance

3.2.5 Concrete infill

Block work shall be bonded to concrete columns, wall and the like with concrete infill B250. block must be stopped in graded shape (10-15 cm from the concrete face) one 8 mm bar must cast in columns during casting with total length 40 cm fixed every 42 cm horizontally, in addition to two vertical 10 mm bars.

The prices inserted in the Bills of Quantities for the masonry works and payment thereof shall be based on net finished specified dimensions of the work and shall include the cost of all testing, mix design, trial mixes, construction, concrete infill and transporting, placing compacting, curing, surface finishing, protection, construction and expansion joints and all labors and materials and tests.

3.3 GLASS BLOCKS

Glass block walls are self-supporting and not load bearing, so a lintel provides the head for the panel to be anchored into whilst ensuring no downward pressure is placed on the glass blocks.

Maximum deflection of structural members supporting glass block panels shall not exceed $L/600$.

Openings must be square and perpendicular with dimensions that designed to suit the glass blocks modules. 10mm mortar joints are the most commonly used.

The glass block walls are connected to the surround by reinforcement bars being inserted into pre-drilled holes (or panel anchors that installed into four sided)

Between the opening and glass block it is essential to incorporate expansion joints to the perimeter to allow the panel to expand and contract freely with temperature change.

Sills of all panels must be painted with a heavy coat of asphalt emulsion and must cure for two hours before first mortar bed is placed.

The foam must not be bridge by mortar (render/plaster...etc.) and caulked with rods and mortar expansion joint sealer (fire-retardent in fire-rated applications).

Glass blocks should not be installed when the surrounding temperature is 5 °C and falling or 30 °C and rising.

Submittals

The following submittals and samples shall be carried out by the contractor for the engineer's review and approval:

- Submit two (2) copies of manufacturer's literature and two (2) copies of manufacturer's installation instructions.
- Submit two (2) glass block units of each type specified, showing size, design and pattern of faces.
- Submit representative samples of (panel reinforcing), (panel anchors), (expansion strips), and (sealant).

Storage and Protection

Store unopened cartons of glass block in a clean, cool, dry area. Protect opened cartons of glass block against windblown rain or water run-off with tarpaulins or plastic covering.

Accessories

Panel Reinforcing: two parallel 9 gauge wires either 1⁵/₈ inch or 2 inch on center with electrically butt-welded cross wires spaced at regular intervals, hot dipped galvanized after welding or Type 304 stainless steel.

Panel Anchors: 20 gauge perforated steel strips 24 inches long by 1¾ inches wide, hot dipped galvanized after perforation or 22 gauge by 16 inches long by 1¾ inches wide of Type 304 stainless steel.

Expansion Strips: made of polyethylene foam with a thickness of 3/8 inch.

Asphalt Emulsion: a water-based asphalt emulsion.

Sealant (caulk): non-staining, waterproof mastic, (silicone), (urethane or approved type).

Packing (Backer Rods): polyethylene foam, neoprene, fibrous glass or equal as approved by sealant manufacturer.

Perimeter Expansion Joints

Glass blocks will expand and contract by 0.25mm per 25°C temperature change. Soft expansion joints must be incorporated into the perimeter between the substrate opening and block, being caulked with a white silicone (or fine-stop mastic). This will visually look similar to a standard mortar joint. For the head and jambs of an opening, 10mm thick foam is used. This is a white expansion fibre. The horizontal expansion joint between the first row of glass blocks and the base of the opening is formed using high-density bitumen to support the weight of the panel.

Joint Sizes and Spacer Pegs

10mm is the most common joint size for specifying and building glass blocks. The spacer pegs are used to prevent mortar squeeze, increasing the number of courses that can be constructed in a day. They prevent stainless steel reinforcement bars coming into direct contact with the glass block as metal and glass have different expansion and contraction properties.

When a spacer peg is fitted and the wall is finished, the tabs at the end twist off and grouted over.

Panel Reinforcement and Tying Back To The Perimeter Opening

Stainless steel ribbed reinforcement bars are used to tie to the opening. The rods penetrate the expansion material and anchor the panel in place by connecting to the perimeter frame. This can be located by drilling an oversized hole of a minimum depth of 25-34mm and should be filled with silicone to cushion any movement of the re-bar.

One reinforcement bar should be used in each horizontal and vertical joint as a minimum. In case where connecting the rods to the opening may prove difficult, panel anchors can be used, similar to the block-tie principle secured by either screw or bolt fixing or can mechanically shot fired.

Glass Blocks Specialist Mortar

Per-mix mortar for glass block construction can be used to ensure accuracy and consistency of performance. It is used as bedding and pointing mix.

When using Per-mix mortar, the surrounding temperature should not be 5 °C and falling or 30 °C and rising and the joint width should not exceed 22 mm.

As the glass is impervious unlike concrete blocks, therefore mortar is not absorbed into a glass block. The strength and support of a joint is created by the shape of the mortar profile (oval). The edge or collar of a block is concaved so when two are laid next to each other an oval joint is created. This oval joint enables the glass block wall to resist impact or applied loads resulting in the panel being stable and self-supporting.

In situ mixed mortar can be used subject to the use of Portland Cement and lime. Mortar shall be 1 part Portland Cement, ½ part lime, and sand equal to 2¼ to 3 times the amount of cementitious material (cement plus lime), all measured by volume.

Preparation

Verify that (channels), (panel anchors) have been provided at head and jambs for the purpose of providing panel anchorage within the opening.

Mix all mortar components to a consistency that is drier than mortar for ordinary masonry. Re-tempering the mortar after it has taken its initial set shall not be permitted. Do not use antifreeze compounds or accelerators.

Freshly mixed mortar may create skin irritation. Avoid direct contact where possible and wash exposed skin areas promptly with water. If any mortar gets into the eyes, rinse immediately with water and get prompt medical attention.

Installation

- A. Cover sill area with a heavy coat of asphalt emulsion. Allow emulsion to cure at least 2 hours before placing mortar.
- B. Where panel anchors are used at jambs and heads in lieu of channel or chase surrounds, install panel anchors in the same joints (16 inches o.c. maximum starting after first course) where panel reinforcing will be laid. Panel anchors are to be embedded a minimum of 12 inches into the mortar joints.
- C. Place or adhere expansion strips to jambs and head. Make certain expansion strip extends to sill and covers leg of panel anchor that is attached to jambs and head.
- D. Set a full mortar bed joint, applied to sill.
- E. Set lower course of block. Maintain a uniform joint width of $\frac{1}{4}$ to $\frac{3}{8}$ inch plus or minus $\frac{1}{8}$ inch. All mortar joints must be full and not furrowed. Steel tools must not be used to tap blocks into position. Place a rubber crutch tip on end of trowel to tap block into position. Do not realign, tap or otherwise move block after initial placement.
- F. Install panel reinforcing every 16 inches o.c. maximum (starting after the first course) in the horizontal mortar joints. Run reinforcing continuously from end to end of panels. Lap reinforcing not less than 6 inches whenever it is necessary to use more than one length. Do not bridge expansion joints with reinforcing.
- G. Place full mortar bed for joints not requiring panel reinforcing – do not furrow. Maintain uniform joint width.
- H. Set succeeding courses of block. Spaces at head of panel and jambs must remain free of mortar for caulking with sealant.
- I. Use only wooden or rubber tipped tools when tapping glass blocks into place.
- J. Strike joints smooth while mortar is still plastic and before final set. Remove surplus mortar from faces of glass blocks and wipe dry. Tool joints smooth and concave before mortar takes final set. At this time, remove and clean out all excess mortar from jambs, head and other locations.
- K. After final mortar set (approximately 24 hours), install packing tightly between glass block panel and jamb and head locations. Leave space for sealant.
- L. Apply sealant evenly to the full depth of recesses as indicated on the drawings and in accordance with the manufacturers' published application manual and instructions.
- M. All exterior glass block panels shall be well sealed to prevent water entry.

Cleaning

- A. Remove surplus mortar from the faces of the glass block at the time joints are struck or tooled. **Mortar should be removed while it is still plastic** using a clean, wet sponge or an ordinary household scrub brush with stiff bristles.
- B. **Do not use harsh cleaners, acids (of any strength), abrasives or alkaline materials while cleaning glass block. Never use a wire brush to remove mortar from glass block surfaces.**

- C. Final mortar removal is accomplished with a clean, wet sponge or cloth. Rinse sponge or cloth frequently in clean water to remove abrasive particles **that could scratch glass surfaces**. Allow any remaining film on the block to dry to a powder.
- D. After all sealants, caulking, etc., have been applied, remove excess caulking materials with commercial solvents such as xylene, toluene, mineral spirits or naphtha and follow with normal wash and rinse. Be careful not to damage caulking by overgenerous application of strong solvents. Comply with solvent manufacturers' printed directions on label for toxicity and flammability warnings.
- E. Final cleaning of glass block panels is accomplished after they are completely installed. Wait until panels are not exposed to direct sunlight. Start at the top of the panel and wash with generous amounts of clean water. Dry all water from the glass block surface. Change cloth frequently to eliminate dried mortar particles or aggregate **that could scratch the glass surface**. To remove the dry powder from the glass surfaces, use a clean, dry, soft cloth. For stubborn or hard to remove powder or stains, the use of an "extra fine" steel wool (grades 000 or 0000) is suggested. Try this first in an unobtrusive area.

4 -PLASTER WORK

4.1 GENERAL

This section of the specifications covers plaster work related with the drawings, bill of quantities, and as directed by the engineer.

The contractor shall attend upon other trades and protect all work specified under this section from damage during subsequent operations, make good any defects, clean away debris upon completion and through out leave all work in perfect condition to Engineer's satisfaction.

Damaged or defective materials shall not be used in the works.

Any defective materials or materials damaged during or after installation shall be removed and replaced at the contractor's expense.

All materials shall be of approved make, and samples shall be submitted for engineer's approval. These materials shall include but not be limited to all kinds of cements, sand, additives, metal lath, galvanized plaster beads, and galvanized wire mesh.

4.2 Gypsum Plaster

4.2.1 MATERIALS

The cement and water used for plastering shall comply with BS specifications. The sand for plastering shall be clean, fine sand and shall be chemically and structurally stable. The sand shall be sieved and graded in accordance with the Table of Grading given below "table 4-1":

Table 4-1: Aggregate Percentage Passing for Plastering

BS Sieve No.	SIZE Inches	Approximate Millimeters	% PASSING	
			Undercoat	Finish Coat
7	0.095	2.4	95-100	100
14	0.047	1.2	80-95	95-100
25	0.024	.6	30-55	30-85
52	0.012	.3	5-50	5-50
100	0.006	.15	0-10	0-10

Note: The above figures represent the limits of percentages (by weight) passing sieves of the sizes mentioned.

The gypsum plaster shall be of the hemi-hydrate type with a controlled setting time. The resultant plaster shall be chemically inert when set, be capable of being troweled to a smooth surface and shall be highly resistant to cracking and crazing. Imported lime shall be of the hydrate type.

4.2.2 Mixing

The mixing shall be done mechanically. With regard to the lime mortars gauged with cement, the addition, just before use of the cement to small quantities of the lime/sand mix shall preferably take place in a mechanical mixing shall continue for such time as will ensure uniform distribution of materials and uniform color and consistency. It is important to note that the quantity of water used

shall be carefully controlled. Gypsum plaster shall be mixed in a clean pail or other approved vessel. The required amount of water shall be placed in the pail and the plaster added gradually and allowed to soak for 5 minutes. It shall then be stirred to a uniform consistency free from lumps and no more material shall be mixed than can be used in half an hour.

4.2.3 Workmanship

All plastering shall be executed in a neat workman like manner. All races except circular work shall be true and flat and angles shall be straight and level or plumb. Plastering shall be neatly made good up to metal or wood frames and skirting and around pipes or fittings. Angles shall be rounded to 5-mm radius. Surfaces of undercoats shall be well scratched to provide a key for finishing coats. Screed marks or making good on under-coats shall not show through the finishing coats. Surfaces described as trowled smooth shall be finished with a steel or celluloid trowel to a smooth flat surface free from trowel marks. Surfaces described as floated shall be finished with a wood or felt float to a flat surface free from trowel marks.

All tools, implements, vessels and surfaces shall at all times be kept scrupulously clean and strict precautions shall be taken to prevent the plaster or other materials from being contaminated by pieces of partially set material which would tend to retard or accelerated the setting time.

4.2.4 Internal & External Plaster

4.2.4.1 Samples

The contractor shall provide samples for all plaster layers before starting work within appropriate time to get approval by the engineer.

4.2.4.2 Preparation of Surfaces

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

All small openings in walls resulted from electrical and plumbing establishments shall be closed using (1:3 cement: sand) mortar.

Plastering shall not be commenced until the background has been suitably prepared. Block work joints shall be deeply raked out, efflorescence brushed off and all dust and foreign matter removed.

Where cement plaster is to be applied to surfaces shall first be dashed with a mixture of Portland cement and sand (1:1) mix to form a key. All surfaces shall be thoroughly sprayed with water and this shall be allowed to thoroughly dry out before the next coat is applied.

Before plastering is commenced all junctions between differing materials shall be reinforced. This shall apply where walls join columns, where brick walls join block walls and similar situations where cracks are likely to develop and as directed by the engineer. The reinforcement shall consist of strip of galvanized wire mesh (10 to 15mm hexagonal mesh) 15cm wide which shall be plugged, nailed or stapled as required at intervals of not exceeding 40cm at both edges.

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 cubic meter of sand shall be applied and allowed to dry before rendering is commenced.

The contractor can use either (hyrib) or (expanded metal) type. The (hyrib) shall fix using overlapping and compressing method, but the expanded metal shall fix using strong nails.

The Contractor shall form vertical guide screeds 5cm wide.

The spacing shall not exceed 1.50 meters.

The screeds shall be plumb and in the same plane with each other. The sides of the screed shall be left rough to bond ~ with plaster, the surface shall be smooth.

The finished surface shall be true and shape and angle even in all directions, with straight arises free of cracks and trowel marks and to the entire satisfaction of the Engineer.

4.2.4.3 Application of Internal Coats

The internal plaster consists of 3-coats which are:

- First layer: (Key Coat)

This layer "Key Coat" is not less than 3 mm with (1:1) cement: sand mortar. This layer must be done by force throw out the mortar to all surfaces. It must be curing for minimum 3-days to keep it moist.

- Second layer: Base-Coat (Rendering)

Base coat shall be done for one wall in same time by using vertically ruler with 10cm width, starting from floor to roof.

When applied to masonry or to concrete surfaces the base coat shall be applied with sufficient force to prevent air pockets and to secure a good bond.

The base coat thickness shall not less than 13mm, with (1:3:0.25) cement: sand mortar: lime.

The base coat shall be lightly scratched in both directions to provide a key for the finishing coat and shall be kept moist with a fog spray for minimum 3 days and then allowed to dry out.

- Third layer: Finishing Coat

Shall not be applied until the rendering or base coat has seasoned for seven days, just before the application of the finish coat, the rendering or base coat shall be wetted evenly with a fog spray.

Finishing coat thickness is about 3mm with (1:4:0.50) cement: sand mortar: lime.

The used sand shall consist of about 50% of soft sand (selisi sand).

Where cement plaster with a smooth troweled finish is specified or indicated on the drawings, the finish coat shall be first floated to a true even surface, then troweled in a manner that will force the sand particles down into the plaster and with the final troweling, leave the surface finished smooth and free from, rough areas, trowel marks, checks or other blemishes.

Cement plaster in all other spaces, where a smooth finish is not specified or noted on the drawings, shall be given a sand float finish or a uniform texture, as approved by the engineer.

The finish coat shall be kept moist with a fog spray for at least two days, and thereafter shall be protected against rapid drying until properly and thoroughly cured.

Plaster shall be made good up to frames and skirting and around fittings and pipes. Angles shall be rounded to a 5mm radius.

4.2.4.4 Application of External Coats

The external plaster consists of 4-coats which are typically specify as same as internal plaster except that the second layer is the concrete coat. Concrete coat thickness is 5mm, with (1:2) cement: sand mortar and shall be kept moist with a fog spray for minimum 2 days and then allowed to dry out. Then base coat and finishing coat are same as in internal plaster.

4.2.4.5 Proportions for Internal and External Plaster

Screeds shall be laid and ruled as necessary to allow for a total thickness of 13-15mm for internal and external plaster and the rendering shall be applied to the required thickness.

4.2.4.6 Tyrolean Plaster (Fine Grain)

The Tyrolean plaster shall be executed to the extent shown on the drawings and as directed by the engineer.

The contractor shall set up samples of different degrees of fineness for the engineer's approval prior to commencement of Tyrolean work. The engineer may choose different degrees of fineness for different parts of the works and the contractor shall allow for this in his rates.

Mixing

Cement and aggregate for each batch shall be accurately measured and mixed dry until evenly distributed and the mass is uniform in color. All batches shall be of such size that. They can be entirely used within half an hour. Mechanical mixers of an approved type shall be used for mixing Tyrolean plaster, except when hand mixing of small batches is specifically approved by the engineer. Mechanical mixers, mixing boxes and tools shall be cleaned after mixing each batch and kept free of Tyrolean mortar from previous mixes. Water content shall be maintained at a minimum. Mixing shall be continued until plasticity is obtained.

Proportions

Proportions of materials for Tyrolean, by volume shall be as follows:

Finish Coat

- 1 part of white Portland cement
- 3 parts fine selected aggregate (Quartz)

Workmanship

Surface to receive Tyrolean shall be clean, free from dust, dirt, oil, or other particles that might interfere with a satisfactory bond. Surface to receive Tyrolean shall be evenly dampened (not soaked) with a fog spray before Tyrolean is applied. If surfaces become dry in spots, the dry areas shall be dampened again to restore uniform section. Tyrolean coats shall be applied continuously in one general direction without allowing mortar to dry at edges. Edges to be jointed shall be dampened slightly to produce a smooth confluence. Tyrolean, unless otherwise shown or specified, shall be two coats work not less than 5mm. thick

All exterior corners of Tyrolean shall be slightly rounded. Tyrolean on soft surfaces shall be pitched forward to form a drip

Surface of the scratch coat shall be dampened several hours before the finish coat is to be applied. Additional dampening at time of application shall be by fog spraying. Dampening by brush will not be permitted. When measured with a 2 meter long, straight edge applied in all directions, the finish surface shall not vary from a true plane by more than 1.5mm. The finishing coat shall be applied by means of a proper spraying machine and the degree of the finishing coat shall be determined by the engineer.

Curing

As soon as the finish coat has taken its initial set, the Tyrolean shall be protected against direct rays of the sun or rapid drying for at least 10 days. During this time Tyrolean shall be kept moist by frequent fog, spraying. Care shall be taken to prevent staining of the Tyrolean.

Acceptance and Repairing

Tyrolean with cracks, blisters, pits, checks or discoloration will not be accepted. Tyrolean shall be clean and sound and in accordance with the requirements of the specifications. After all other related work has been completed, pointing around trim and set work and repairing of damaged portions shall be performed to the satisfaction of the engineer. Repairs shall match existing Tyrolean in texture and color to the satisfaction of the engineer.

4.2.4.7 Colored Plaster

The colored plaster shall be executed to the extent shown on the drawings and as directed by the engineer.

The contractor shall set up samples of different degrees of fineness for the engineer's approval prior to commencement of colored plaster work. The engineer may choose different degrees of fineness and colors for different parts of the works and the contractor shall allow for this in his rates.

Surface preparation

The external coats for external surfaces shall be carried out as specified previously. The surface where the final colored plaster will be applied, must be clean, dry and free of disintegrating materials or impurities and dust, mold and oils.

Exposed materials or parts shall be removed by using high-pressure washing or using any suitable mechanical method.

Mixing

Mortar shall be mixed in a medium speed with a suitable electrical stirrer to make sure the homogeneous structure before use. Material, which has begun to harden, should not be used.

Application

One coat of acrylic basis shall be painted before applying the material.

The rendering material shall be applied to a thickness not less than 15 mm in one coat. Where the thickness is expected to exceed 15mm it should be applied in multiple coats. When more than one coat to be applied, it is important that the previous coat of plaster should be cured for at least two days and the surface must be scratched in order to receive the further coats of plaster firmly on it.

Curing

The plaster should be protected from low temperatures, direct rainfall or direct sun lights during the curing time.

4.3 False ceiling from galvanized mesh and plastering

1. Fixing the approved galvanized mesh as template from metal rods with diameter 8mm every 25cm in both sides which must weld with each other by electrical weld.
2. Check up the fixing mesh to ensure it's horizontally is good. Then covering it by 3-coats of rough plaster with 1cm thickness for each coat. Each coat shall be lightly scratched in both directions and wait until it dry to start with the second coat. The third coat is fine plaster coat with thickness 0.5cm. The final thickness for 3-coats is 3.5cm.
3. The used mortar for all 3-coats shall consist of (1:3) cement: sand mortar with adding laxative approved material.

The metal grid system shall be a patent system suitable for use with in-situ plaster and expanded metal lathing and shall have flat metal hangers to suit suspended ceilings depths as shown on the drawings and described in the Bill of Quantities. The system shall include all main and cross runners,

necessary splicer, hangers, clips and wall mounting next to walls. The system shall be installed complete in accordance with the manufacturer's instructions.

5 -TILING WORKS

5.1 Materials

Portland cement, fine aggregate and water shall be as previously specified in section 3, concrete works.

The colour pigments shall be of an approved manufacture, lime-proof and non-fading and complying with British Standard No. 1014: 1942.

The marble chipping shall be of an approved quality in irregular pieces varying for 0.047" to 3/8" in size depending on the effect required. The pieces should preferably be roughly cubical in shape and flaky shaped pieces shall not be used.

The granite chipping shall be of an approved quality graded from 1/2" down with not more than 5% fine material passing a No. 100 sieve.

Marble and granite aggregates shall comply generally with table and granite aggregates shall comply generally with table of grading. In connection with marble aggregates, the percentages are approximate only. The actual grading should be selected to produce the surface effects required as shown in table 5-1.

Table 5-1: Aggregate Percentage of Passing for Tiles

B.S. Sieve No.	Sieve opening		Percentage of Passing	
	inch	mm		
-	1/2	13	100	-
-	3/8	10	59-100	59-100
-	3/16	5	30-60	25-60
7	0.095		20-50	5-30
14	0.047	1.2	15-40	0-10
25	2.40	0.6	10-30	-
52	0.012	0.15	5-50	-
100	0.006	0.3	0-5	-

Note: The above figures represent the limits of percentages (by weight) passing sieves of the sizes mentioned.

5.2 Mixing

Materials for in-situ paving and locally manufactured tiles shall be measured separately in approved gauge boxes on a clean, dry, level surface.

Materials shall be mixed either by hand or machine as previously specified in Section 3, concrete works.

5.3 Proportions

The following mixing table 5-2 shall be strictly adhered to in all castrations will be permitted only when demanded by the particular Specification for individual works or prior written consent of the

Engineer.

Table 5-2: Mixing of Tiles composites

Nominal mix	Cement Kilos	Fine Aggregates Cu.M.
1:1	1442	1.00
1:2	721	1.00
1:2 ½	577	1.00
1:3	476	1.00
1:4	361	1.00
1:5	289	1.00

5.4 Granolithic Paving

These shall consist of a (1:2 ½) mix-one part Portland cement to two and half parts of granolith 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-see the concrete shall first well cleaned wetted and brushed with a Portland cement grant.

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

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

Covering them with Hussein wet for seven days shall cure granolithic paving.

5.5 Cement and sand paving

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

The paving shall be laid in bays as prescribed above for granolithic paving.

Cement and sand paving intended as a wearing surface shall be troweled twice with a mechanical 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.

5.6 Cement and sand tiles

These shall be formed with a (1:2) mix of white or colored cement, or in white cement with a colour pigment added, and sand applied as a facing not less than 7 ½ mm thick to a Portland cement and sand (1:5) mix backing. The tiles shall be cast in heavy metal moulds under pressure to the proportions and sizes shown in the following table 5-3.

Table 5-3: Grinding of Granite and Marble Chipping

B.S. Sieve No.	Sizes of sieve		Percentage passing by Weight	
	mm	Inches	Granite Chipping	Marble Chipping
-	13	½	100	-

B.S. Sieve No.	Sizes of sieve		Percentage passing by Weight	
	mm	Inches	Granite Chipping	Marble Chipping
-	10	3/8	95-100	95-100
-	5	3/16	30-60	25-60
7	2.4	0.095	20-50	5-30
14	1.2	0.47	15-40	0-10
25	0.6	0.24	10-30	-
52	0.3	0.12	5-50	-
100	0.15	0.006	0-5	-

It is essential that closer grading limits be selected for the marble chipping if a consistent and uniform surface texture is desired.

Coloured cement and sand skirting to match tiles, 10cm or 20cm 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 laid and bedded direct on to a concrete sub-floor on a cement and sand 1:4 mix screed. This screed shall be 2 ½ cm thick in the case of 2 ½ cm tiles and 3cm thick in the case of 2cm tiles. The total thickness of cement and sand screed and tiles shall not exceed 5 cm. All tiles shall be laid with square joints.

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 2 ½ cm thick in the case of 2 ½ cm tiles and 3 cm thick in the case of 2cm tiles. The total thickness of cement and sand screed and tiles shall not exceed 5cm. 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 net cement of a color to match the tiling. Any surplus grout shall be cleaned off the face of tiling and surrounding surfaces immediately and all tiling shall be carefully cleaned off.

5.7 Terrazzo Tiles

These shall be formed with a (1:2 ½) mix of white or colored cement or white cement with a colour pigment added and granular marble chipping applied as a facing not less than 6mm thick to a Portland cement and sand 1:5 mix backing.

The tiles shall be cast in heavy metal moulds under pressure to the proportions and sizes shown in the following table 5-4.

Table 5-4: Terrazzo Tile Dimensions

Size (cm)	Min Wear Surface(mm)	Size tolerances (mm)	Total Thickness (mm)
20x20	6	±0.5	20
25x25	6	±0.5	25
30x30	8	±1.0	30
40x40	8	±1.0	30
Skirting	6	±0.5	10

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 neat cement grout of the same colour 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 7cm, 10 cm or 20 cm high with chamfered top edge shall be produced in the same way as for tiles using the same mixes.

The contractor has to clean the place prior to starting the tiling works and get the approval from the engineer to laying clean sand 5 cm

Terrazzo tiles shall be laid and bedded on a cement and sand (1:4) mix screed. This screed shall be 2 ½cm thick in the case of 2 ½ tiles and 3cm thick in the case of 2cm tiles. The total thickness of the cement and sand screed and tiles shall not exceed 5cm. All tiles are laid with square joints.

Terrazzo tiles shall be laid only if it's age more than 30 days from that the date of manufacture.

The tiles shall be laid dry and tamped into the slurry to form a level surface. Joints shall be even and not more 3 mm wide in both directions.

All tilling shall be grouted up on completion, care bing taken to fill all joints completely. The grout shall consist of neat cement of a colour to match the tilling. Any surplus surfaces immediately and all tilling 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 6mm thick as the following table 5-5:

Table 5-5: In-Situ Terrazzo Dimensions

Item	Min Wear Surface(mm)	Total Thickness (mm)
Stair Tread	10	50
Stair Riser	6	20
Stair Skirting	6	20
Sill	10	50
Threshold	8	30

Terrazzo stair treads should be reinforced with at least 2 longitudinal bars Ø6mm for each and glass joints will be installed along the cast in situ terrazzo.

5.8 Marble Paving

Marble paving shall generally be 2-3 cm thick the size, type and pattern that be as stated in the particular specification, BOQ and/or shown on the drawings.

The marble slabs shall be fixed solid on a bed of cement and sand 1:4 mix 3cm thick tight joints grouted in lime putty. Protective slurry of putty at least 3mm thick shall be applied to the marble paving and subsequently cleaned off.

Treads to stairs shall be 3cm thick fixed solid on a bed of cement and sand 1:4 mix 3cm thick Risers to stairs shall be 2cm thick fixed solid on a backing of cement and sand 1:4 mix 3cm thick. Window sills shall be 3cm thick fixed solid on a bed of cement and sand 1:4 mix 3cm thick. Skirting shall be 1cm thick in lengths equal to the tile length, fixed solid on a backing of cemented sand 1:4 mix 2cm thick. Joints in skirting shall be arranged to coincide with joints in adjacent paving. Rounded arises, noising and moldings shall be adequately protected by means of timber casing or lime putty ceilings. Treads, risers, skirting and windows 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.

5.9 Marble linings

Marble linings to walls, columns and the like shall generally be 2cm thick and the size, type and pattern shall be as stated in the particular specification, BOQ and/or as shown on the drawings. The marble slabs shall be cut square/rectangular and true and shall be uniform in shape and thickness. Patterns and moldings shall be accurately formed in accordance with the Drawings.

The marble slabs shall be fixed with copper or galvanized steel cramps and hooks and plaster raps leaving an air space of 12mm behind the slabs to prevent transfer of soluble salts from the backing materials. The cramps shall be 2 1/2cm x 5mm x 10mm girth one end and turned down and grouted into mortise in marble and the other end built into wall set 45cm apart in each bed. Mortises shall be accurately and carefully cut and all joints shall be thoroughly grouted.

Exposed edges and molding 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 or other defects.

5.10 Generally

All paving shall be protected from damage during subsequent operations and shall be well washed and thoroughly cleaned before handing over.

5.11 Terrazzo Tiles Testing

The test sample should be randomly selected so that 0.5 per one thousand but not less than 6 tiles per 500 m². In case two tiles or more of the sample don't match the specification, then the whole shipment is rejected. But if one tile failed, then replication of the test should be proceeded.

The Terrazzo tiles, steps and cast in situ Terrazzo must be tested according to the international standards and as follows: -

- Specific Gravity: not less than 2.5
- Water Absorption: Absorption should not be more than 8% by weight for each sample.
- Flexural Strength: It should not be less than 5 N/mm² for each sample.
- Wear Resistance: Rate of wear resistance should not be more 2mm on average for 3 samples of each batch. However, each sample should not have wear resistance over 2.5 mm.

5.12 Tiles and Cladding

All the tiling & cladding works will be executed according to the drawings and engineers instructions and will be tested to control the quality of the materials as mentioned in the general specifications. *Unless otherwise said in the BOQ and drawings, the tiling will be:*

Terrazzo tiles (local production):

- Terrazzo (marble chips) floor tiles size 25x25x2.5cm.
- Terrazzo (marble chips) skirting 1x7cm.

Marble Works:

- Local marble (Class A) 3cm thick will be used for WC doors entrances, main entrances and any other places indicated in the contract documents.
- Local marble (Class A) copings 3cm thick will be used for staircases and roof parapets.
- Local or imported marble 30x60x2cm tiles or any size requested by the engineer will be used for flooring.
- Colored marble or granite 2.0cm thick with sizes as requested by the engineer.
- Windows sills will be local marble 3 cm thick (Class A).

The kitchen cabinets :

- Local marble 2cm thick (Class A) will be used for shelves, floor and back of the kitchen cabinets and 3cm thick for vertical dividers and the worktop will be from approved marble or granite, the cupboard leaves will be of colored aluminum.

West Bank stone: -

- West Bank stone of Class A will be used as shown in the drawings, specifications of stone works and the engineer's instructions.

5.13 Marble and Granite

The test sample should be randomly selected so that not less than one tile per 100 tiles.

The marble and granite must be tested according to the international standards and as follows: -

- Specific Gravity: not less than 2.5
- Water Absorption: Absorption should not be more than 0.75% by weight for each sample.

5.14 Ceramic, Glazed and Quarry Tiling.

Samples of tiles shall be submitted to Engineer for approval of quality and color prior to order.

Clay floor quarries and fitting shall be in accordance with BS 1286 Type A and the thickness and size shall be as stated in the Drawing, BOQ or as per the engineer approval.

Ceramic floor tiles and fitting shall be in accordance with BS 1286 Type B and the thickness and size shall be as stated in the Drawing, BOQ or as per the engineer approval.

Glazed ceramic floor tiling shall be of the type, thickness and size as stated in the Drawing, BOQ or as per the engineer approval.

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

Semi-dry cement and sand (1:4) mortar shall be spread not less than 4 cm thick as tiles bedding.

Cement and sand mortar bed (1:3) not more than 2 cm shall be laid. Any admixture to the mortar must be approved before used.

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

Tiles shall be firmly tamped into motor to form a level surface. Joints shall be even and not more 3 mm wide in both directions using spacer lug tiles or spacer pegs.

Joints shall be continuous and extended vertically.

The tiles shall be grouted up with white or colour cement motor worked well into joints when bed is sufficiently firm to prevent disturbances of the tiles; surplus grout shall be cleaned off from faces of tiles.

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

Tiles shall be cleaned off and polished once completion.

5.15 Glazed Ceramic Wall Tiling

Walls tiles shall be in accordance with BS 1281 first quality and a minimum thickness of 6mm.

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 engineer.

The tiles shall be immersed in water for 6 hours or until saturation tightly together to drain with end tiles turned.

Key layer cement and sand (1:2) then scratched screed (1:4 mix) should be applied preceding to tiles installation.

Ceramic floor tiles shall be soaked and bedded in cement and sand mortar (1:3 mix) with addition of an approved plasticizer.

Tiling shall be carried out to the levels indicated on the drawings in a first class workmanship.

The render coat shall be wetted sufficiently to prevent it absorbing water from the bedding coats.

Thickness of finished bedding shall be not less than 6 mm nor more than 12 mm.

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

Joints shall be even and not more than 3 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 2 m.

Tiles shall be neatly cut and fitted around pipes and other obstructions.

Tiles shall be grouted up to 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 cleaned off and polished upon completion.

5.16 Ceramic Tiles Testing

The test sample should be randomly selected so that 6 per one thousand or less but not more than 15 tiles for every delivery. In case two tiles or more of the sample do not match the specification, then the whole shipment is rejected. However, if one tile failed, then replication of the test should be preceded.

- Water Absorption: Absorption should not be more than 4% and 0.3 by weight for semi glazed and full glazed ceramic respectively.
- Flexural Strength: It should not be less than 5 N/mm² and 6.5 N/mm² for semi glazed and full glazed ceramic respectively.
- Wear Resistance: Rate of wear resistance should not be more 2.5mg/mm² and 1mg/mm² on average for 4 samples of each batch for semi glazed and full glazed ceramic respectively.

6 -METAL WORKS

6.1 Scope

These specifications cover ferrous and non-ferrous works intended to be used in the project; all in accordance with the Drawings and as directed by the Engineer.

The contractor shall ensure of all dimensions on the site and clear them in detailed shop drawings for approval by the Engineer.

The contractor should provide the engineer with detailed shopdrawings for aluminum works that will be installed, in addition to providing samples of profiles, method of statement, accessories and hardware in order to have a written approval prior to starting.

6.2 Materials

6.2.1 Steel

Steel plates, and structural steel shaped sections shall conform to the requirements of B.S. 4 latest edition for structural sections, Part 1 Hot-rolled sections and Part 2 Hot-rolled hollow sections (Metric Series).

6.2.2 Aluminum

The Aluminum used should be approved type by the Palestinian Standards Institute, as indicated in the specifications and Bill of Quantities.

6.2.3 Bolts, Nuts and Washers

Bolts and nuts shall conform to the requirements of B.S. 4190: I.S.O. metric black hexagon bolts, screws and nuts.

Plain washers shall be made of steel. Taper or other specially shaped washers shall be made of steel or malleable cast iron and shall conform to the requirements of B.S. 4320, metal washers for general engineering purposes.

6.2.4 Galvanized Steel Pipes

Galvanized steel pipes shall conform to the requirements of B.S. 1287 - I.S.O. "Medium Series".

6.2.5 Paint

Paint for Metalworker shall comply with the applicable requirements as specified under "PAINTING".

6.3 Description of Steel

Steel to be used for all the works must be new and have never used before and must be free of rust and crusts. The steel bar or plate should not be welded pieces but one unit.

The steel profiles and tubes used should be sound and free of defects like buckling, bending, and cracking or other. The tolerances in sections of steel shall not more than 0.30 mm for thickness and 0.50 mm for other dimensions.

6.4 Description of Aluminum

All of aluminum profiles should be according to the drawings and not be less than the following:

1. The thickness of aluminum profiles used for sliding doors and windows should not be less than $(1.6\text{mm} \pm 0.1)$
2. The thickness of aluminum profiles used for hinged doors and windows should not less than 1.6 mm and not more than 1.8 mm.
3. The thickness of rail for the louvers should not less $(1.6 \text{ mm} \pm 0.1 \text{ mm})$.
4. The thickness of hollow profiles with area more than 3200 mm² should not less than 1.6 mm, meanwhile the hollow profiles which area less than 2200mm² should not less than 1.5mm.
5. The thickness of decoration and architrave profiles should not less than 1.2 mm.
6. The thickness of anodizing coat at profiles should not less than 15 micron at least.
7. The thickness of powder coating at profile should not less than 60 micron at least.

6.5 Manufacturing and fixing of steel works:

6.5.1 General

The Contractor shall be responsible for the correctness and accuracy of the dimensions of the finished items. He shall therefore carefully check the dimensions indicated on the Drawings, verify any change and ascertain the sizes on the site which will enable him to prepare final working drawings for fabrication and erection purpose. Such drawings shall be submitted to the Engineer for his verification and approval.

Fabrication orders can only take place after the contractor obtains, in writing, the approval of the Engineer for the above drawings.

6.5.2 Flush Steel Door and Frame

Flush steel door shall be fabricated of hot-rolled steel sections for framed skeleton with diagonal bracings and lined both faces with steel sheet of thickness as shown on Drawings or stated in the Bills of Quantities, riveted to framed skeleton as shown on the Drawings. The frame shall be made of hot-rolled steel sections and shall be provided with. 8 No. anchors, one end welded to frame and the other end dove-tailed to the masonry or concrete.

6.5.3 Hollow Metal Door Frames

Hollow metal door's frames shall be made of the profiles and sizes shown on the drawings and obtained from an approved manufacturer. The door frames shall be with minimum 2.0 mm thick, twice laminated steel sections and be delivered to site complete with a factory applied anti-corrosive plastic coating., ties cast to backs of frames for building in and rubber silencers on the locking stile.

The frames shall be stored in a clean, dry place, off the ground and protected from the weather.

The frames shall be free of all dents, bumps, splits, and cracks and any defective frames shall be made good or replaced at the Contractor's own expense.

6.6 Workmanship

6.6.1 Aluminum elements

The glass used should be transparent glass with a thickness of 4 mm or if stated otherwise.

The Aluminum used is coated with hot dipped polyester powder (paint thickness should not less than 60 microns).

Aluminum should be colored type and color choice as instructed by supervisor Engineer.

The used flay screen for the aluminum windows is manufactured of fiberglass as specified in drawings and bill of quantities.

Installing of aluminum frames to sills, lintels, and opening sides should be by using wedges manufactured of Polymerized Propylene or using screws made of aluminum or anti rust steel.

Those screws should have enough size and length to fix the frames strongly as required and the approval of supervisor Engineer.

The hardware and accessories should be made of aluminum (Allen key corners, rails, locks, handles... etc.) of the same type of profiles required and shall be of solid hardware durable and shaped.

The used wheel rollers should be spherical ball bearing.

The locks should be secured and from approved type by the manufacturer or supervisor engineer.

The closing kit and tapes used to prevent water and air leakage should be manufactured from polymer vinyl chloride (PVC) or neoprene.

The engineer approval should be obtained for the color and appearance of the coating surface of aluminum before industrialization and supplying materials.

Selection of aluminum forms and profiles used to allow the tight closure of the doors and windows by installing tapes anti-air and weather influences, and providing the frames of sliding doors and windows with holes to permit disposing rainwater.

Aluminum works should not be installed before the completion of plastering and painting finishing.

Gap spaces between aluminum and architectural openings for doors and windows should be packed with a silicon paste injected from both sides to ensure full closure. The color of silicon must be fit to the color of aluminum.

Contact between the surfaces of aluminum and any metal surfaces contrast to the stainless steel, zinc-coated nickel or the bronze nickel is prohibited but only after addressing those surfaces using one coat of poly-zinc chromate primer and two coats of oil painting.

The contractor is responsible for all works of aluminum during and after installation until handing over the project.

Installation of glass must be using strip of rubber between aluminum and glass from inside and outside.

The manufacturer must maintain the corners of aluminum works at right angles and gapless.

6.6.2 Steel elements

All steel works should be done with professional manner and welding must be hidden, not appeared on the face and polished.

All steel parts shall be accurately set out, cut, framed, assembled and executed using proper bolts or welding electrodes. All cut parts shall be sawn cut; no oxygen burning shall be permitted except for pipe supports. All welding shall be electrical welding, clean and of proper workmanship. All cut parts and welded sections shall be ground, even and filed smooth with rounded edges

No allowable showing any signs of knocks or any type of cavity in steel and should be all contact

links arbitrator well without leaving any vacuum or clear signals welding redundant on the face. Forging shall be sharp and true curbs and intersections, members of the same size shall halve together.

All items found in the railway premises in the building by rail to be commensurate with a solid and well.

It must be to work of all holes in block walls, concrete walls, tiles or stairs and where necessary to install steel works strictly by private machineries without causing any damages to the building. Costs of making holes well done and recovered are responsible of contractor with his own costs.

Manufacturing windows and doors as a full specifications and details shown on the drawings, taking into account that fixing 2 hinges for each window's shutter. However, if the height of shutter exceeds 1.5 meters, fix at least 3 Hinges for each shutter. For each door's shutter, fix 3 Hinges, 100 mm length unless otherwise specified in drawings or special specifications.

All steel members in contact with the soil shall paint with two (2) coats of protective asphalt paint. All doors frames staircases, etc... shall be given at least one (1) coat of approved rust inhibiting primer before delivery to Site

Making doors and windows accurately and proficiently duly taking into account that are made all welding by professionals and skilled labors with expertise in this area, and automatically clean all welded links and to get a smooth surface without protrusions

Stored all produced parts prior to installation in a dry place and the process of being transfer without scratches.

The contractor shall provide samples of any section for approval by Engineer before.

Fix door's frames in the wall by steel angles (3mm- thickness, 50 mm- wide, 200 mm- length), and be stationed in the form of right angles by welded one side of angel with steel frame and fix other side of angel with block by cement mortar.

Fix glass to window's frame using metallic clips and rubber or putty.

All work shall be erected plumb and true to lines and rigidly secured to walls, floors or ceilings as shown on Drawings and to the satisfaction of the Engineer

Welding work is along the flat welding (stitching along the line of welding)

6.6.3 Welding

Welding surfaces shall be clean, free cobalt, rust and other materials that will have the opposite effect on the welding by skilled professionals with expertise in this area.

Prohibits a welding operations in the up-normal weather conditions such rain, strong winds, or when temperatures fall to zero (0 °c), unless action was taken to ensure that the impact of these conditions on welding operations, and the approval of Engineer

The intensity of electricity used in welding operations shall be located within the established range of welding rods, and then welding process is the movement of fluctuations consecutive start of the first welding and so close, and being removed from the slag welding operations abreast so that each layer of the welding layers completely clean before the following class action.

Prohibits any subsequent operations for one welding process unless after the disclosure of welding by engineer and approval, and is not being disclosed mentioned before passing 72 hours after the end of operations

Must provide workers with masks, protective glasses and gloves, and necessary to safe them during welding operations

Welding work is along the flat welding (stitching along the line of welding).

Hollow metal door frames

Hollow metal door frames shall be fixed and shown on the drawings all in accordance with the manufacturer's printed instructions and flushed up solid with plain concrete or cement mortar.

The rates for hollow metal door frames are to include for the supply and assembly of the complete unit including all necessary holes for hinges and lock, cutting of torsion threshold bar if necessary and fixing in walls in accordance with the manufacturer's printed instructions and plain concrete or mortar filling as shown on the drawings.

6.7 Ventilation Louvers

Steel ventilation louvers, shall be made to the sizes, dimensions and designs shown on the drawings and fixed to concrete as indicated on the Drawings. Shop drawings shall be prepared to detail fixing and samples shall submit to the Engineer for approval before ordering the materials.

6.8 Iron Steps

The Contractor shall supply and fix galvanized malleable steel iron steps of general-purpose pattern conforming to B.S. 1247, and having a 117mm tail. They shall build into walls truly level and in vertical lines as shown on the Drawings or directed by the Engineer.

6.9 Ladders

Steel ladders shall consist of galvanized mild steel coated with fiberglass or as specified in the B.O.Q and supplied complete with suitable bottom and top brackets and intermediate support brackets at centers not exceeding 20cm.

6.10 Steel hand railing & Balustrades

Unless otherwise specified hand railing and balustrades shall consist of handrails and standards of galvanized mild steel. Handrails shall be flush jointed with an internal screwed nipple joint. Removable hand railing shall be half lap jointed.

Handrails shall be not less than 45mm outside diameter and to rails shall be set not less than 1.05m above adjacent floor or platform level, unless shown otherwise on the Drawings.

Standards shall be tubular and not less than 45mm outside diameter and shall be of the double ball type with balls at approximately equal spacing above adjacent floor or platform level.

Base plates wherever possible shall be horizontal and circular. Horizontal and side palm plates shall be secured (I) by not less than 3 bolts of not less than 12mm diameter and 75mm length. Hand railing, base and palm plates shall be (I) painted after erection. Painting shall deem to including in the Contract rates for hand railing.

6.11 Galvanized steel covers

Galvanized steel covers shall be galvanized mild steel with raised threads of Durbar pattern or similar approved by the Engineer. The plate shall be sufficient thickness to support. A distributed load of 5KN/square meter or shall be as detailed on the Drawings.

The covers shall support on galvanized mild steel frames. The frames shall have mitred and welded corners, with welded fishtail anchors at not greater than 1m centers, all galvanized after fabrications.

Galvanized mild steel lifting handles shall be welded onto the covers where shown on the Drawings.

Locking devices to manhole covers shall be of galvanized mild steel and as shown on the Drawings.

Galvanizing to all covers shall carry out after all welding and fabrication is complete.

6.12 *Permanent fencing*

Permanent fencing if requested shall be installed over the boundary wall and shall be 0.5m overall height consisting of 4 strands of barbed wire. All steel parts shall be galvanized.

The fencing should supply complete with the fixing supports, which must be galvanized steel pipes, 2" diameter.

6.13 *Monorail hoist*

Monorail hoist shall be furnished and installed to the dimensions shown on the drawings. "I" beam shall be used, in accordance to BS 449: Part 2 1969 (Specifications for the use of structural steel in building. (Part 2: Metric Units).

7 -CARPENTRY WORKS

7.1 General

Carpentry work should be executed as shown on drawings and/or described in the contract documents in a proper manner and in accordance with the specification.

The carpenter is to clean out all shavings, cut ends and other timber waste from work places in the building and remove it from the site, all according to the satisfaction of the engineer.

All timber shall be softwood unless otherwise specified.

The contractor shall verify all sizes on the site by measuring all openings in order to cut wood with exact dimensions.

7.2 Description of Work

The extent of carpentry work is as shown on the drawings. The work includes, but is not necessarily limited to, wood grounds, blocking, nails and the like.

7.3 Quality Assurance

Codes and Standards: Comply with the applicable requirements of following codes and standards:

APA - American Plywood Association.

AWPB – American Wood Preservers Bureau.

U.L – Underwriter's Laboratories.

7.4 Particular

Timber for carpentry work shall be of species and quality suitable for the purpose for which it is to be used.

Samples of every type of timber which the contractor proposes to use in the work shall be sent to the engineer for approval. Each sample shall be labeled and the label shall state the species of the timber and the purpose for which it is to be used.

Timber shall be square, straight, true and shall be free from the following defects:

- Splits, ring checks and soft pitch.
- Hair cracks exceeding 0.25mm wide.
- Checks exceeding 30cm long.
- Checks more than half the thickness of the timber in depth.
- Knots exceeding 1cm mean diameter and/or exceeding 1m distance between their.
- Any size of knots in small timber species.
- Knots exceeding half the width of the surface.
- Decayed dead knots.
- Pitch pockets.
- Loose knots or knot holes.
- Decay and insect attack.
- Moist timber.
- Oil squeezer in timber which is still moist.

The soft wood generally shall have a moisture content limit of 15%. The hardwood shall have a moisture content limit of 10% and shall have been kiln dried unless otherwise specified. The whole of the timber for joinery work shall be properly stacked and protected from rain and ground moisture.

Where preservation treatment is specified in the contract:

The moisture content of the timber immediately prior to treatment shall not exceed 28% and the

timber shall be free from surface moisture and dirt. Treatment is to take place after all cutting and shaping is complete, and care must be taken not to damage surfaces of treated timber. If surface damage or cutting after treatment is unavoidable a liberal coating of preservative is to be made to such areas.

The preservative treatment shall be either:

Creosote applied by vacuum/pressure to BS 144 and 913, or

Copper/ chrome/ arsenic slats applied by vacuum/pressure to BS 4072.

7.5 Submittals

1- Submit shop drawings show full dimensions of each member. Show details of connections, connectors and other accessories. Indicates species and stress grade and other variables in required work.

2- Wood Treatment Data: Submit chemical treatment applied and manufacturer's instructions for proper use of each type of treated material.

3- Pressure Treatment: For each type specified, include certification by treating plant stating chemicals and process used, net amount of salts retained and conformance with applicable standards.

4- For water-borne preservatives: include statement that moisture content of treated material was reduced to maximum of 15% prior to shipment to the project site.

5- Fire-Retardant Treatment: Include certification by treating plant that treatment material complies with governing regulations and that treatment will not bleed through finished surfaces.

7.6 Product Delivery, Storage and Handling

1- Keep carpentry materials dry during delivery, storage and handling. Store lumber and plywood in stacks with provision for air circulation within stacks. Protect bottom of stacks against contact with damp surfaces. Protect exposed materials against weather.

2- Do not store dressed or treated lumber or plywood out-doors.

7.7 Materials

7.7.1 Timber

1- General: Timber for framing, blocking etc., shall be sound, well conditioned, properly seasoned to suite the particular use and free from defects or combination of defects rendering it unsuitable for the purpose intended. Unless otherwise indicated, timber shall be No.1 yellow pine or No.1 fir.

2- Moisture Content: 15% maximum.

7.7.2 Plywood

1- Concealed Plywood shall be Exterior Type, C-C Grade.

2- Exposed Plywood shall be Exterior Type with medium density overlay on exposed faces.

3- Electrical Panels: If required for backing panels of electrical and communication equipment, provide Interior type plywood with exterior glue, fire-retardant treated.

7.7.3 Anchorage and Fastening Materials

Provide approved type, size, material and finish for each application.

7.7.4 Plywood Covered With Veneer

These sheets are formed of odd layers where each one is perpendicular to the underlying layer and

should be ex-factory made with minimum total thickness 4mm unless otherwise specified.
In case of 3-layers for plywood sheet; it is not permitted to exceed the thickness of middle layer than 60% of total thickness of plywood sheet.
But if the plywood sheet consists of more than 3-layers, the total thickness of the two faces and those enclosed layers in which its fibers are in the same direction of faces' fibers; is ranged between 40% and 60% of the total thickness of sheet.
The contractor shall get the approval of the engineer for the source of the plywood sheets.
It is not permitted to combine plywood sheets with thickness less than the specified thickness by any means in order to get the required thickness.
The plywood sheet shall be free from any defects.
The faces of plywood sheet shall be of hard or smooth veneer as per specifications and bills of quantities.

7.7.5 Adhesive material

It is recommended to use highly adhesive material with approval of the engineer.

7.7.6 Plastic Sheets (Formica)

Use fire and moist proof sheets with approved color either shining or mutt. The used sheets shall be approved Britain made or equivalent like (Formica, Arborybe, Upper stop, etc.).

7.7.7 Nails and screws

- 1- Use nails with appropriate section and length for the work, and do not use weak or bend nails.
- 2- Use Rawl Plug or Rawl Plastic with nails to fix the wood as recommended by the manufacturer.
- 3- Soft wood is not permitted for plugs and wedges, only hard wood should be used.
- 4- Use copper, or chrome nails in case of visible nails, and do not use steel nails in this case.

7.8 Job conditions

- 1- Time delivery and installation of carpentry work to avoid delaying other activities which is dependent on or affected by the carpentry work and to comply with protection and storage requirements.
- 2- Framing, furring, nailing, blocking, grounds and similar supports should be performed so that the work will comply with design requirements.

7.9 Wood Preservative Treatments

- 1- General: treatment of lumber and plywood, where required or indicated as “Treated”, is to comply with the applicable requirements of the American Wood Preservers Bureau (AWPB), available form AWPI.
- 2- Pressure treat the following items with waterborne preservatives for above-ground use, should comply with AWPB LP-2:
 - Wood cants, nailing, blocking, stripping and similar members in connection with roofing, flashing, vapor barriers and waterproofing.
 - Wood blocking, furring, stripping and similar concealed members in contact with masonry or concrete.
 - Kiln-dry wood to a maximum moisture content of 15% after treatment with water-borne preservatives.
 - Pressure treat wood members placed in the ground with below-round water-borne preservatives, complying with AWPB LP-22.

7.10 Fire Retardant Treated Wood

- Where fire-retardant treated plywood is specified, comply with AWPB standards for pressure impregnation with fire-retardant chemicals to achieve a flame spread rating of not

more than 25 when tested in accordance with UL Test 723, ASTM E 84, or National Fire Protection Association (NFPA) Test 355.

Where transparent or paint finish is shown or scheduled for treated wood, use a fire-retardant treatment which will not bleed through or adversely affect bond or finish.

- Complete fabrication prior to treatment, wherever possible, to minimize cutting and jointing after treatment. Coat surfaces cut after treatment with a heavy brush coat of the same fire-retardant chemical.
- Kiln-dry lumber and plywood to a maximum content of 15% after treatment.
- Inspect each piece of plywood after drying; do not use twisted, warped, bowed or otherwise damaged or defective pieces.
- Provide UL label or other equivalent on each piece of fire-retardant treated wood.

7.11 Inspection

The contractor shall examine the substrates and the conditions under which carpentry work shall be carried out and correct any unsatisfactory conditions.

Do not proceed with the work until unsatisfactory conditions have been corrected in a manner acceptable to the Engineer.

7.12 Workmanship

Timber shall be cut and blocked early by enough time to let the wood dry prior to forming.

Sections of timber used in the carpentry work are the net dimensions after cutting, scraping and rubbing the timber.

Make connections with Mortise and Tenon (dove & tail) way and use approved adhesive material to fix them with appropriate wooden nail if necessary.

Through assembling the door components including door frame; use Mortise and Tenon not less than 20mm in length.

Wooden parts should be painted with two coats of primer prior to installation.

Fix wooden frame to the wall using galvanized steel angels (120mm length, 30mm width & 4mm thick) by fixing the angel in the frame using screws and in the wall using cement mortar.

In case of fixing the wooden frame in concrete member; use expandable screws (Philips) with 100mm length and 5mm thick. The screws shall be sunk in the frame and the holes shall be filled with glue mixed with sawdust.

The minimum thickness of frame is 45mm. The frame shall exceed the wall width by not less than 15mm from both sides of wall to fit with plaster work, or 20mm in case of fixing ceramic wall tiling.

Use white cold bitumen coat for maximum 100mm height from bottom of frame legs as well as the back of frame as for moisture protection.

All framing shall be jointed as shown on the drawings, as specified by specification or approval by the engineer.

Hinges shall be designed and fixed so that they will transmit the loads and resist the stresses to which they will be subjected.

Unless otherwise stated; hinges shall be secured with a sufficient number of nails of an approved type.

Use 3-hinges with minimum 100mm length to fix the door with frame. The hinges should be made of brass metal.

All connections exposed to the weather shall be thickly primed except where adhesive materials are used.

No nails, screws, or bolts shall be placed in an end split. If splitting is likely to occur, holes for nails are to be pre-bored at diameters not exceeding 4/5 of the diameter of the nail.

Members of structural units shall be clamped and spiked together before drilling bolt holes. Holes for bolts shall be bored from both sides. A tolerance of 1mm will be allowed in positioning bolt holes.

Timber connectors, where specified, shall be 2 single sides toothed plates for demountable joints and one double sides toothed plate for permanent joint.

Timber shown on the drawings to be plugged shall be properly and securely fixed by means of splayed or expansion bolts.

Timber shall not be built into walls or floors unless this is shown on the drawings. When required, it shall be coated with a wood preservative material suitable for the position in which the member is to be incorporated.

7.13 Installation

1-General: Discard units of material which are unsound, warped, bowed, twisted, improperly treated, not adequately seasoned or too small to fabricate the work with a minimum of joints or the optimum jointing arrangement.

2-Shop Drawings: Comply with details shown on approved shop drawings. Provide lumber and plywood of dimensions not less than those shown.

3- Fit carpentry work to other work. Scribe and cope as required for accurate fit.

4- Set carpentry work accurately to required levels and lines with members plumb and true.

5- Securely attach carpentry work to substrates by anchoring and fastening as shown and as required by recognized standards.

- Provide washers under bolt heads and nuts in contacts with wood.
- Nail plywood to comply with recommendations of the American Plywood Association.
- Countersink nail heads on exposed carpentry work and fill holes.

6- Fasteners:

- Use common wire nails, except as otherwise shown or specified herein. Use finishing nails for exposed work. Do not wax or lubricate fasteners that depend on friction for holding power. Select fasteners of size that will not penetrate members where opposite side will be exposed to view or will receive finish materials. Make tight connections between members.
- Install fasteners without splitting of wood, predrilled as required. Do not drive threaded friction type fasteners; turn into place. Tighten bolts and lag screws at installation and retighten as required for tight connections prior to closing or at completion of work.

7.14 Wood Grounds, Nailing, Framing and Blocking:

1- Provide wherever shown and where required for screeding or attachment of other work. Form to shapes as shown and cut as required for true line and level of work to be attached or screeded.

2- Coordinate location with other work; refer to shop drawings of such work, if any.

3- Attach to substrates securely with anchor bolts or other attachment devices as shown and as required to support applied loading. Counter sink bolts and nuts flush with surfaces, unless otherwise indicated. Build into masonry as work progresses, cutting to fit masonry unit size involved. Anchor to formwork before concrete placement.

4- Provide grounds of dressed deys-beveled lumber not less than 38mm wide and the thickness required to bring face of ground to exact thickness of finish material involved. Remove temporary grounds when no longer required. Where indicated as permanent grounds, provide treated lumber.

7.15 Wooden door

Make the wooden door according to approved shop drawings.

In case of flush compressed doors, make the internal fillers from white wood with 3cm maximum distance between fillers, and 3cm minimum width for each one. Make the architraves using hard wood unless otherwise specified.

Forming fillers as specified in the drawings and make a tongue through the longitudinal part of the frame with minimum 1cm length.

Doors which their connections include gaps, shall be rejected.

7.15.1 Wooden doorframe

Use class (1) wood to make the frames with appropriate width and 4.5cm thick with appropriate architraves from both sides of the frame.

Fix the frame with 10cm minimum length under the tiling level.

Coat the frame with primer coat then two coats of white cold bitumen for the back and buried part before fixation.

7.15.2 Metal accessories

Use high quality accessories for doors made of brass or chrome, approved by engineer.

Use first class, approved quality locks and handles according to the type specified in the particular specifications.

8 -PAINTING WORKS

8.1 SCOPE

The Specifications cover paint work to exposed concrete and plastered surfaces, wood work, ferrous and non-ferrous surfaces in accordance with the schedule of finishes, drawings and bill of quantities and as directed in writing by the Engineer.

The term “Paint” as used herein includes emulsions, enamels, lacquers sealers and other coatings, organic or inorganic, whether used as prime intermediate or finish coats.

All painting works shall be applied by skilled workmen experienced in this work.

8.2 MATERIALS

8.2.1 Materials in General

The materials to be used shall be of the best quality and of approved types, obtained from an approved manufacturers *and these material approved from “the ministry of Public works and population”*.

All paints shall comply with the following requirements:

- The product shall be thoroughly mixed.
- The color of the paint shall match the approved sample.
- Paint shall show no evidence of cracking, chipping or flaking.
- Paint in the containers during and after application shall not be abnormally pungent, offensive or disagreeable.
- Paint shall show easy brushing, good flowing and spreading and leveling properties. These properties shall be demonstrated on test specimens at the request of the Engineer. Coats that have any noticeable pull under a large brush and that show poor spreading and flowing properties will not be acceptable.
- Paint shall dry to a uniform, smooth, flat or Semi-gloss finish under ordinary conditions or illumination and wearing. There shall be no laps, skips, high-lighted spot or brush marks. Tinted paints shall dry to a uniform color.
- Recoating of a previous painted surface shall produce no lighting softening or other film irregularities.
- Paint materials should be tested by an authorized and approved laboratory in compliance with the B.S or Palestinian Standard.

8.2.2 Flint-coat Protective Coating

Flint-coat protective coating on fire escape staircase floors shall be colored, “Decorate”. The product of “Flint-coat” or approved equivalent shall be especially compound acrylic resin latex color coating, heavy bodied, flexible and abrasive resistant.

8.2.3 Knotting

Shall be composed of dissolving shellac or other resin remains unaffected by the resinous materials in the timber leaching into the paint film and causing discoloration or defective drying.

8.2.4 Mordant Solution

Shall be composed of a solution slightly acidic in nature and containing solvents, for applying to new smooth metallic surface to remove grease, organic soaps and provide a physical key and shall be obtained from an approved supplier.

8.2.5 Fillers

Shall be "Polyfilla " or approved equal.

8.2.6 Stopping

Shall be hard stopping composed of white lead paste, and other fillers obtained from an approved supplier.

8.2.7 Putty Filler

Shall be composed of white lead and dry filler mixed with pure linseed oil, the content of the white lead shall be not less than ten percent (10%) of the mixture by volume and shall be obtained from an approved supplier.

8.2.8 Thinners

Shall be approved turpentine or white spirit, except where the paints are specified to be water thinned, fresh water shall be used.

8.2.9 Stain

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

8.2.10 Color

Shall be pure tiny color that will easily dissolved and mix with the various coatings and shall conform to the requirements of B.S. 1014: 1961 "Pigments for cement, magnesium oxy-chloride and concrete".

8.2.11 Primers

Primers applied to surfaces of different materials shall be as follows:

- Interior or exterior plastered surfaces: Alkali resistant primer as recommended by the manufacture.
- Ferrous Surfaces: Lead based or zinc Chromate and Calcium Plum bate as recommended by the Manufacturer.
- Non-ferrous surfaces: Mordant solution of an approved brand and rust inhibiting primer.
- Woodwork Surfaces: Leadless grey primer in accordance with B.S. 2524 latest edition.

8.2.12 Undercoating Paints

For exterior or interior shall be as follows:

- One coat of whitewash or color-wash as shown on the Schedule of Finishes and the Drawings.
- White lead bases undercoating in accordance with B.S. 2525, Colors shall be similar to the finishing paint.
- Other undercoating paints to be applied as recommended by the manufacturers of the finishing paint.

8.2.13 Finishing Paints

Shall be as follows unless otherwise indicated on the Drawings:

- Interior plastered surfaces and exposed concrete surfaces as shown on the Schedule of finishes and the drawings:
Float enamel paint or approved emulsion paint for interior use of an approved color and supplier.
- Exterior exposed and plastered surfaces as shown on the Drawings:
Approved emulsion paint for exterior use of the color indicated on the Drawings.
- Interior woodwork surfaces other than hardwood:
Oil paint semi-gloss finish of an approved manufacturer.
- Hardwood surfaces:
Approve oil stain and ducco spray, or flat enamel paint.

8.3 WORKMANSHIP STATIONARY

8.3.1 General

The Contractor shall submit to the Engineer for approval; the brand and quality of the paints he proposes to use.

If approval is given to a brand of paint the contractor shall use the primers, undercoats etc... manufactured or recommended by the manufacturers of that brand.

All paints to be used under this contract shall be delivered and stored on the Site in sealed, labeled containers, a minimum of 30 days prior to application by the contractor. As the materials are in the Site, samples of each material shall be obtained at random from sealed container by the Engineer in the presence of an authorized representative of the contractor.

Samples shall be clearly identified by commercial name, type of paint and intended use. If judgment is necessary by the Engineer the paint samples may be tested in a laboratory designated by the Engineer at the contractor's expense, complete color charts for the paints to be used shall be submitted to the Engineer for approval.

Pigmented paints shall be furnished in containers not larger than 25 kgs. All paints shall be produced that have a minimum of 2 years satisfactory field services.

Mixing and application of paint shall be in accordance with the Specifications of the manufacturers concerned, and to the approval of the Engineer.

The mixing of paints 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 Engineer.

Hardware, hardware accessories, machine surfaces, plates, lighting fixtures and similar items in place prior to cleaning and painting, which are not intended to be painted, shall be removed or protected prior to painting operations and repositioned upon completion of painting work as directed by the Engineer.

Equipment adjacent or against walls shall be disconnected by workmen skilled in these trades and moved to permit the wall surfaces to be painted, and following completion of painting shall be replaced and reconnected.

Cleaning solvents shall be of low toxicity. Cleaning and painting shall be so programmed that dust and other contaminants from the cleaning process will not fall on wet or newly painted surfaces.

Brushes, pails, kettles, etc... used in carrying out the work shall be clean and free from foreign matter. They shall be thoroughly cleaned before being used for different types or classes of material. No exterior or exposed painting shall be carried out under adverse weather conditions such as rain, extreme humidity, dust storms, etc.

Painting shall preferably be shaded from direct sun light to avoid blistering and wrinkling.

Wherever possible, painting of exterior surfaces shall “follow” the sun such that it is carried out in shadow.

Edges, corners, crevices, welds and rivets shall receive special station to insure that they receive an adequate thickness of paint.

All cracks and holes shall be cut out properly square and made good with suitable hard plaster or cement sand mix as appropriate such repaired portions being allowed to dry out and sandpapered smooth.

8.3.2 Plastered Surfaces with Emulsion or Enamel Paint

Such works shall be allowed to dry out completely before carrying out the painting operation. Plaster applied in the winter season shall be at least five weeks old and that applied in the summer shall be at least two weeks old before commencing painting operations.

Preparation of surfaces shall consist of vigorous brushing and rubbing down to remove loose surface material and dust.

Surfaces shall then be left for a week to determine whether efflorescence re-appear in which case it shall be brushed of dry and a further waiting period of one week allowed.

Alternatively, the surfaces may be neutralized by brushing on a solution of 3 percent phosphoric acid and 2 percent zinc chloride and removing all loose particles after drying. No painting shall be carried out until the Engineer is satisfied that no efflorescence is occurring.

Where required by the Engineer one or two coats of “Alkali resistant” primer shall be applied, sufficiently thinned to penetrate the surface.

The first coat of stopping shall be applied after the primer coat dried out completely and the second coat after the first undercoat application. Each coat of stopping shall be allowed to dry and harden thoroughly and shall then be rubbed by sandpaper until smooth surface is achieved.

A minimum of two approved undercoats recommended by the manufacturers of finishing coat shall be applied by brushing well into the surface. Each coat shall be allowed to dry and harden thoroughly before the next coat is applied.

The finishing coat of paint shall be applied after the completion and testing of the mechanical and electrical works.

8.3.3 Ferrous Surfaces:

Surfaces shall be thoroughly cleaned to remove dirt, wire brushed and scraped to remove scale and rust. One coat of approval putty shall be applied on the surfaces and left to dry for at least twenty four (24) hours; surfaces shall then be rubbed by sandpaper or other approved means before primer is applied.

One coat of rust inhibiting “Galvanized” primer or other approved equal shall be approved equal shall be applied by brushing well into the surface and shall be allowed to dry and harden thoroughly before the application of subsequent coats.

If ferrous works delivered primed, the surfaces shall be examined to ascertain that the primer coat is hard. If not satisfactory the primer coat shall be removed and the surfaces cleaned to remove grease and dirt and reprimed as described above for ferrous. Abraded spots on shop-coated surfaces shall be wire-coated surfaces, shall be wire-brushed and touched up with same materials as the shop-coat.

The undercoat and finishing coat shall be chlorinated rubber paint interior or exterior grades and used all in accordance with the directions of the approved manufacturer.

Chlorinated rubber paint, interior or exterior grades, shall not be applied in damp, foggy or freezing weather or to any surface which is not perfectly dry. Ferrous surfaces shall be thoroughly cleaned free of all rust, scale, dirt, oil and grease, etc....

Brush application is recommended although this material may be sprayed if desired, only special thinners produced by the approved manufacturer may be added to achieve the spraying consistency required.

Special approved thinners may be used for cleaning brushes after use.

Ferrous works such as frames, covers to expansion joints, etc... which are to be built into walls shall be primed before installation.

8.3.4 Non-Ferrous Surfaces

Galvanized steel surfaces to be painted shall be solvent-cleaned or painted with mordant solution and shall be primed with Poly-zinc before the application of paints as described above for ferrous surfaces.

8.3.5 Wood Surfaces

Wood surfaces except surfaces to be given natural finish or other finish specified shall be primed, undercoated twice with undercoating paint as recommended by the manufacturer of finishing coat and final coat with semi-gloss enamel paint of approved manufacturer.

Wood surfaces shall be scrubbed with abrasive paper to obtain a smooth surface. Surface mould where exist shall be removed by washing, rubbing down and burning off as necessary. Oil wood shall be swabbed with white spirit. Resinous exudation and large knots shall be removed and replaced by approved filler or knot sealer and the surface shall be primed.

Parts of wood to be enclosed in walls shall be primed unless already impregnated with creosote or other preservative. Priming shall be brushed on and a minimum of two coats applied to end grain. After the primer coat is hard, all cracks, holes, open joints, etc... shall be made good with hard stopping and rubbed with fine abrasive paper. If the first process of stopping found to be unsatisfactory it shall be repeated after the first undercoating is applied and well it shall be repeated after the first undercoating is applied and well dried.

Priming of joinery shall be applied only on the site after the Engineer has approved such joinery and before it is fixed. The two undercoat paints shall be applied on wood doors, panels, etc. before they are fixed, to ensure that the bottom and top edge and sides are thoroughly painted. The finishing coat of paint to such wood doors, panels etc... shall be applied after fixing in position and as directed by the Engineer.

Wood surfaces specified as stained shall only be rubbed down with fine abrasive paper and two coats of oil stain deco sprayed to the satisfaction of the Engineer.

Wood surfaces specified as varnished shall be thoroughly cleaned down of all dirt, oil, grease, etc... and rubbed to a smooth finish, knots shall be treated with knotting and 2 coats of approved oil varnish applied.

8.3.6 Flint coat Protective Coating

Two coats of flint coat Decorate colored coatings should be applied at normal dilution i.e.: two (2) volumes Decorate and one (1) volume water, using no primer. The first coat should be allowed to dry before applying the second one.

8.3.7 Oil Stain Finish to Woodwork

The stain finish to woodwork shall be an approved manufacturer's oil stain system applied strictly in accordance with the manufacturer's instructions.

All surfaces are to be thoroughly dry and cleaned and sanded down and all nail holes or similar

defects shall be filled and leveled up with approved hard stopping

The finish shall be applied in two coats. The first coat shall be pigmented stain wax brush applied. The surface shall be allowed to dry for 2-10 minutes and then rubbed with a cloth in rotary motion to remove excess stain and produce an even surface.

The first coat shall be allowed to dry completely before application of the second coat.

The second coat shall be natural (clear) stain wax and buffed.

The Engineer shall select the stain color and the contractor shall allow for preparing sample panels for the Engineer's approval and these sample panels will provide the standard for the work.

9 -ROOFING, WATERPROOFING AND THERMAL INSULATION

9.1 SCOPE

These specifications cover, waterproofing, roofing and thermal insulation to be used for underground structures, floors and roof decks required for the Works in accordance with the Drawings, Bills of Quantities and as directed in writing by the Engineer.

9.2 Preparation

All surfaces must be clean sound, and free from oil, grease and all loosely adherent materials. Wire brush, sand blast or grit blasting may be used to remove any surplus adhered to concrete and steel. The contractor must submit a request for all materials for Engineer approval.

9.3 MATERIALS

9.3.1 Damp proofing

All substructures, floors of ground floor of kitchens, toilet and bathrooms have to be painted with a waterproofing liquid.

Before application of primer and bituminous layers, angle fillets of concrete should be constructed at the wall boundary of the bathroom, toilet and kitchen with dimension of 7 cm* 7 cm and working mix cement & sand by 1:3. Thresholds of the same mix must be implemented at the bathroom, toilet and kitchen doors.

9.3.2 Waterproofing of exterior walls

This will be added to the exterior plastering of walls. It's an integral concrete waterproofing compound that will reduce moisture absorption in the plastering mixture.

In case of buried masonry, the joints between courses should be ranked out to 0.5cm, and then the walls to be plastered with rich cement mortar 0.5cm thick by 1:1 cement –sand ratio.

The bitumen primer should be applied after the plastering is totally dried and left enough time as per instructions of the manufacturer. Two coats of hot bitumen 75/25 should be applied perpendicular to each other, unless otherwise indicated, so that any holes, cracks or any defects are not been noticed.

In case of concrete walls; any loose particles and steel ties should be removed and accordingly patched with special cementeous material prior to application of the primer and bituminous coats as previously described.

9.3.3 Waterproofing of the roof

Lightweight Concrete

A sloping screed consisting of lightweight concrete screed shall conform to B.S.3797: lightweight aggregate for concrete. The lightweight aggregate shall be such a Vermiculite, Alveolite, etc.... aggregate of an exfoliated micaceous mineral aggregate incombustible and chemically inert, obtained from an approved manufacturer, graded and mixed in accordance with the manufacturer's instructions.

The lightweight aggregate shall be delivered to the Site in the manufacturer's sealed and branded containers which shall be clearly marked to show the grade of lightweight aggregate contained therein. They shall be stored in a covered shed with floor raised off the ground and bags stacked not more than 3.00 meters high.

Process of damp-proofing layers should not be started at least four days after curing of concrete screed finished and dried.

Cement angle fillets 10cm * 10 cm must to be executed at the boundary of roof parapet with cement & sand mix by 1:3

Mixing Proportions

The lightweight concrete screeds shall be measured, mixed applied and cured in accordance with the manufacturer's instructions and to the satisfaction of the Engineer.

Gauges boxes shall be used for the measurement of light- weight aggregate and the following mixing table 9-1 shall be strictly observed.

Table 9-1: Mixing of light- weight aggregate

Nominal Mix	Lightweight Aggregate	Cement Contents	Water
8:1	1:00 Cubic Meter	150 kgs.	200 Liters

As overall, the maximum bulk dried density of the lightweight concrete should not exceed in anyhow 1200kg/m².

Mixing Methods

Mixing may be carried out by hand or by approved machine in accordance with the following procedures:

By Hand

The measured quantity of lightweight aggregate shall be poured out onto a clean dry level surface and sufficient water added only to give workability. Mixing shall be carried out until the water has been distributed amongst the lightweight aggregate. The cement shall be added and further mixing shall take place until all materials are uniformly distributed.

By Machine

The machine used for mixing shall be an approved countercurrent rotating paddle type mixer operating at the speed recommended by the manufacturer. The water shall be placed in the mixer followed by the lightweight aggregate and mixing shall continue until the water has been distributed amongst the lightweight aggregate.

The cement shall then be added and further mixing shall take place until all the materials are uniformly distributed.

It is extremely important to ensure that the mixing period is kept as short as possible in order to prevent compression of the lightweight aggregate. For this reason ordinary concrete mixer of the revolving drum type are unsuitable and shall not be used.

If an approved mixing machine is not available then the mixing shall be carried out by hand.

It is also important that the water content be kept to the minimum possible to allow for the proper hydration of the cement. Sloppy mixes shall not be used. An even consistency free from lumps and excess water is required. As a Site test for consistency, a handful of the mix when firmly gripped should just release water.

Placing of the lightweight concrete mix shall take place immediately after mixing. The lightweight concrete screed shall be laid to falls in alternate bays not exceeding 16.00 square meters in area to a minimum depth of 50mm. The lightweight concrete mix shall be carefully spread by means of a rake to a depth 12.5% greater than the finished thickness required and shall then be lightly troweled down

to its finished thickness. The mix shall not be tamped, vibrated or compressed with heavy implements.

The lightweight concrete screed shall be cured by covering with damp Hessian for a period of seven days and during this time the screed shall not be subjected to traffic to any kind.

After curing the light weight concrete screed shall be protected by a layer of cement and sand (1:4) mix. This topping shall be well troweled in to ensure proper adhesion with the lightweight concrete screed and shall have a minimum finished thickness above the lightweight concrete screed of 30mm and shall be finished flat and true with a steel trowel.

The screed and topping shall be water cured with damp hessian for a period of 7 days then left for 4 days drying before receiving waterproofing system.

Alternatively the cement and sand topping may, with the approval of the Engineer be applied immediately after troweling the lightweight concrete screed. Lightweight concrete screed, cement and sand topping shall not be laid during rain.

9.3.4 Waterproofing

An application of Plastomeric Bitumen-Polymer waterproofing sheets (APP) with splayed chips must be carried out after application of corresponding primer as instructed by the manufacturer. Membranes should not be less than 4mm in thickness or 4.5kg/m².

Application process of the membranes must be done by torching them to the specified temperature prior to adhering to the roof deck. The pricing will include overlapping 10cm between sheets, upstands up to 15cm, dressing into storm water traps, etc.

Measurement of the membrane and underlay screeds will be for the horizontal projection of the deck unless otherwise described

9.3.4.1 Workmanship

Prior to the beginning of the roofing works, the Engineer and the roofing superintendent shall proceed to the inspection and approval of the receiving surfaces, the upstands at roof edges, the drains, vent pipes and other venting devices, the construction joints etc.

The contractor will be notified in writing of all defects of the flat surfaces or details and work shall not be preceded until such defects have been corrected.

One coat of primer is painted over the entire surface. Installation of the bituminous layers shall be carried out in conformity with the manufacturer's specifications and using propane torch welding only.

Asphalt coatings shall be softened but not melted as to avoid superheating using a single-nozzle torch of adequate size. Rolls shall overlap 75mm on sides and 150mm at ends. All inadequately welded seams will be refused. All superheated areas or parts will be refused

and will require adequate repair in accordance with the degree of deterioration of the membrane.

Air blisters, wrinkles impact and tearing marks and protective granules pounding marks are not admissible. Should these defects occur, roofing works shall be carried out again.

9.3.4.2 Bituminous Flashings

A plain underlay bonded to the support with previously applied primer coating or welded to it with propane torch. This underlay shall be unrolled parallel to the upstanding element in one meter width extending 150mm onto the current surface underlay.

Apply the current surface-finishing layer onto the flashing underlay and then recover with the flashing-finishing layer extending 200mm onto the current finished surface.

This layer shall be welded with propane torch in full adherence that no air is entrapped between layers. Side and end laps shall be staggered over underlay seams and 75mm wide.

9.4 WATERSTOPS

9.4.1 General

Rubber water stops or PVC water stops shall be provided in the joints in concrete where shown on the Drawings. If not shown on the drawings the minimum width of the water stop shall be 200mm.

The Contractor shall submit with his Tender a detailed description of the water stop he intends to use, accompanied by a drawing showing the shape and size of the water stop, the name of the manufacture, and the methods to be installing and splicing the water stop, which shall be in accordance with the requirements detailed below.

The Contractor shall also furnish all labor and materials for making field splices in all water-stops. The Contractor shall take suitable precaution to support and protect the water-stops during the progress of the work and shall repair or replace any damaged water-stop.

All water-stops shall be stored in as cool a place as practicable, preferably at 21 C⁰ or less. Water-stops shall not be stored in the open or where they will be exposed to the direct rays of the sun. All water-stops shall be protected from oil or grease.

9.4.2 Rubber Water-stops

The rubber water-stop shall be fabricated from a high-grade, tread-type compound. The basic polymer shall be natural rubber or a synthetic rubber. The material shall be compounded and cured to have the following physical characteristics: yield strength 10.2 N/mm², elasticity of 400% at braking strain.

9.4.3 Installation

The water-stop shall be installed with approximately one-half of the width of the material embedded in the concrete on each side of the joint. Care shall be exercised in placing and vibrating the concrete about the water-stop to insure complete filling of the concrete forms under and about the water-stop, and to obtain a continuous bond between the concrete and the water-stop at all points around the periphery of the water-stop. In the event the water-stop is installed in the concrete on one side of a joint more than one month prior to the scheduled in date of placing the concrete on the other side of the joint, the exposed water-stop shall be covered or shaded to protect it from the direct rays of the sun during the exposure. Before placing the concrete on the other side of the joint the projecting half of the water-stop shall be carefully cleaned.

The contractor shall take suitable precaution to support and protect the water-stops during of the work and shall replace at this own cost all damaged or deteriorated water-stops.

9.5 THERMAL INSULATION

Criteria, design aspects, implementation methodology and relevant materials of the thermal

insulation must be according to the Palestinian Code for Energy Efficient Building and using the supplementary Guidelines.

10 -STONE WORKS

10.1 Introduction

The masonry stone is one of the oldest building materials known in the history of construction that had strongly influenced the architectural style and construction system in the Middle East.

By given the unique quality of the masonry stone, it is considered as one of the most prevailing and essential items in the building construction until the twentieth century as introduced other materials. Natural masonry stone has several sources in the world especially in the Middle East including Jordan, Palestine, Saudi Arabia, Morocco and other.

The masonry stone specifications cover all the stone works intended to be used for external walls including the decorations at elevations, architectural openings, arches, and copings covering the parapet of the roof.

All these required works should be in accordance with the drawings, bills of Quantities and as directed in writing by the supervisor Engineer.

10.2 Categories of stone in Palestine

10.2.1 According to the classification of compounds, which contains:

- Stones contain wire mainly stone such as quartz
- Stones containing silicate minerals and other silicate minerals that contain Feldspar which is aluminum silicate with lime and potassium with color red or pink, or containing aluminum silicate with iron then the color becomes brown black.
- Calcareous stones contain minerals which are either calcite (calcium carbonate) or dolomite with a calcium magnesium carbonate.

10.2.2 Classification by region of stone:

- Al Shoyokh stone, this type of stone is extracted from Hebron, which is more common in Gaza Strip.
- Kabatia stone, this type of stone is extracted from Jenien.
- Anjasa stone, this type of stone is extracted from Hebron, which is most common in the Gaza Strip.
- Jamma'in stone, this type of stone is extracted from Nablus, which is a high price stone, and hard formation with a high quality).
- Yatta stone, this type of stone is extracted from Hebron.

10.2.3 Classification by engraving formats:

The masonry stone is craved in multiple formats including:

10.2.3.1 Stippled stone (Milattash) format

This type of stone format is achieved by engraving all over the stone surface using a pointed carving chisel distributed regularly as possible.

The depth of Stippling groove should not be more than 3 mm in stone class A, and 5 mm in stone class B and C.

10.2.3.2 (Misamsam) stone format

This type of stone format is achieved by engraving the stone surface using a fork head chisel equal and parallel lines horizontally or vertically or at angle of 45 degrees.

The depth of groove should not be more than 3 mm in stone class A, and 5 mm in stone class B and C.

10.2.3.3 Rough stone (Tobzeh) format

This type of stone format is achieved by keeping the stone in its original rough surface, but refining works should be done around the edges of the stone.

The depth of refining works should be more than 90 mm from the edges and not less than 50 in stone class A, and 40 in stone class B and 30 in stone class C.

10.2.3.4 (Tabbih) stone Format

This type of stone formats is achieved by engraving intensively as required on the stone surface using a spiky-head hammer grade 10, 12, or 14 to keep it free of cavities, or other stone defects.

10.3 Advantages of natural stone

1. Color consistency and not influenced by natural erosion agents
2. Thermal insulation and firmness and durability
3. Maintain the natural form and flair.
4. Lack of need for maintenance.
5. Relevance for all weather conditions.

10.4 Defects in stone

1. Holes: in the form of pockets within the stone make it a weak over time.
2. Impurities: in the form of pockets within the stone filled with shells.
3. Seams: a shakes within the stone filled with materials mainly crystallized calcium carbonate.
4. Races: the pockets filled with lime which distorts the stone and makes it weak as well.
5. Irregularities of colors: the regular color of stone is very important advantage in terms of architectural appearance and durability of stone, that determining the acceptance of stone or not.

10.5 Stone Industry

The stone industry process is going through several stages.

1. Extracting of natural stone from stone quarries in the form of blocks that go through cutting process to the required sizes and volumes.
2. Stone carving using different kinds of chisels. The stone surface should be chipped manually to be fitted with the required formats.
3. If a saw is used in the Stone cutting process, the inner edges of stone should bi-chipped to increase the contact between the stone and the backfilling concrete.

10.6 Materials

10.6.1 Technical Specifications for masonry stone

1. The masonry stone in its different shapes and formats that intended to be used in walls construction should be of high quality and free of defects such as holes, impurities, seams and shakes, races, irregularities of colors, structural weaknesses and other defects that would tend to increase unduly the deteriorations from natural causes.
2. Should be regular in color, and remains constant through the time.
3. Samples of stone materials and dressing shall be submitted for the Engineer's approval 30 days before delivery of any such material to the Site.
4. All stones shall be selected well in advance of the time required and passing through the

physical and laboratory test as the following table:

Table 10.1 : Illustrates the Test Parameters and Values for the Masonry Stones

TEST	STANDARD	TEST TIME (DAY)	CLASS A	CLASS B	CLASS C
Dry density g/cm ²	ASTM C97	3	2.56	2.45	2.16
Compression Resistance kg/m ²	ASTM C170	2	800	700	600
Flexural Resistance kg/cm ²	ASTM C99	3	55	47	28
Sear Resistance kg/cm ²	ASTM C97	3	6.9	5.2	3.4
Erosion & abrasion	ASTM C241	3	≤1%	≤1%	≤1%
Water absorption	ASTM C97	3	3%	4.3%	7.5%

5. Stone Dimensions

- The height of mason stone is 25 cm or 12.5 cm and other sizes can be selected depending on the nature of the project.
- The masonry stone length should be between 35 – 70cm, while the length of small pieces that used to complete the facade should not be less than 1.5 stone height.

6. Stone thickness: The thickness of masonry stone according to the Jordanian specifications should be between 5 - 7 cm of the stone used in the facades building and 3 cm of the stone used in the facades cladding or tiling.

10.6.2 Backfilling Concrete:

The backfilling concrete used for the Stone construction should be concrete (B-150) where the design compressive strength of the concrete should not be less than (185 kg / cm²) and the quantity of cement at a minimum of (260 kg / m³).

10.6.3 Wire meshes reinforcement

Wire mesh reinforcement of spacing 20cm*20cm and ø8 mm should be fixed to the façade concrete block by anchors with distance does not exceed 60 cm in two directions.

10.7 Workmanship

The contractor should provide stone samples for the engineer approval and the approved stones to be kept with the engineer during of the implementation of the work until completion, and should set up mockup of the stone facade for the Engineer's approval before executing any pointing.

The total thickness of stone building and concrete backing shall be as shown on the approved shop drawings.

All stones shall be cleaned and thoroughly wetted before setting up.

The back surface of the stone should be chipped well in terms of increasing the contact between stone and concrete.

All stone courses should be hand placed, carried up in a uniform manner. Not more than 2 courses are allowed to rise above one another at the same time .The joints must be solidly bedded with full mortar and fully squeezed out.

The mortar for bedding will consist of mixture of cement, fine aggregate size (1.18mm), and clean sand with ratio 1:2:1 respectively.

The period of time allowable for using the mortar in masonry stone works should not be more half an hour

The vertical overlapping between stone courses should not be less than 25cm unless otherwise

mentioned.

The horizontal and vertical joints between stone courses should be 5mm in width, and to ensure even and regular width of beds and joints when setting up stones. The Contractor shall use hardwood wedges to ensure close and regular gaps between beds and joints.

The horizontal and vertical joints should be straight and perpendicular to each other and should be cleaned and grooved in depth of not less than 1.5 cm.

All stone courses, stone arches, and any architectural decorations should be well supported by convenient shuttering works according to the engineer's instructions and under the contractor's responsibility for any damage occurred of any kind.

A holes of 2.5cm depth (2 holes at least) on the upper surface of each stone , then a galvanized wire of ϕ 4mm, Z-shape should be fixed in the holes with adhesive paste and tied to the wire mesh reinforcement.

Care should be exercised when casting the backfilling concrete behind the stone courses, that should gradually with layers' doesn't exceed 20cm thickness for each layer and in a period of time between layers of 1 hour at least.

Backfilling concrete for masonry stone should be from 5 - 8 cm thickness, unless otherwise mentioned.

Detailed shop drawings for all stone works and installations should be submitted and approved by the supervisor engineer, clarifying the method of installations, dimensions and sizes, types, formats, width of joints, etc.

10.8 Stone cleaning and Joints grouting (TAKHEEL)

After completion of the installation of stone, hardwood wedges should be removed, then the stones are cleaned from the suspended dirt by one of two ways either by sand blasting or by grinder machine with wire brush.

The mortar used for grouting works should be consists of mixture of white cement, fine aggregate size (1.18mm), and clean sand with ratio 1:1:1 respectively, while the coloring of the mortar should according to engineer's instruction.

Types of grouting (TAKHEEL).

1. flush: the grouting should be flat with the face of the stone and polished well.
2. Grooved: the grouting concavity should be half circular with diameter (5 mm) and depth (3 mm) of the surface of the stone.
3. Recessed: the grouting depth and width should be according to instructions and specifications, where the recessed grouting width should not be less than (4mm) of the depth of the joints.

10.9 Quantity measurements for mason stone works

All stone works quantities should be measured by square meter for all kinds, types, stone arches, architectural openings, and façade decorations unless otherwise mentioned, taking in consideration that the price includes the installation of scaffolding duration of the implementation, wire mesh reinforcements works, backfilling concrete works, Stone cleaning and Joints grouting and all needed works according to engineer's instructions .

11 -SUB BASE AND BASE COURSES

11.1 General

Locating sources and manufacturers of materials are the responsibility of the contractor.

Prior to starting quarry or borrow pit operations, the contractor shall obtain written permission from the Authorities or Owner concerned.

The contractor shall submit to the Engineer, 10 days prior to the scheduled beginning of crushing and screening, a statement of origin of all stone and/or gravel aggregates and granular materials.

The contractor shall submit for testing and approval, representative samples of all materials needed. Samples shall be taken by the contractor in the presence of the Engineer. Approval of specific sources of materials shall not be considered as final approval.

The contractor may conduct necessary tests in the Field Laboratory in the presence of the Engineer and the contractor's Materials Engineer.

Samples shall satisfy all specified test requirements. The contractor shall furnish all necessary labor, transport, tools and equipment required by the Engineer.

11.2 Granular Material for Sub-Base

Granular material for use in sub-base courses shall be naturally occurring gravel, blended as necessary with fine or coarse material and screened to produce the specified gradation. Crushing of natural granular material shall not normally be required, unless for the purpose of meeting the gradation requirements, or when shown on the Drawings (to produce a higher quality sub-base with improved mechanical stability).

Gravel shall consist of hard, durable and sound stones, free from deleterious substances not mentioned below.

Other requirements are:

Crystalline gypsum (expressed as SO ₃)	5% max.
Clay lumps and friable particles	10% max.

Flakey and elongated particles

Crushed rock	40% max. Each
Crushed gravel	45% max. Each
Natural gravel	50% max. Each

Determined in accordance with BS812 Section 105.1: 1985 and BS812 Part 1 1975)

Maximum dry density

Maximum dry density is **2.05gm/cm³** as min.

Chart content (determined by percentage by weight insoluble in hydrochloric acid) should be specified in special technical specification.

Granular materials delivered to the road site shall meet the requirement of class A or B as shown in Table 3.1, when tested in accordance with AASHTO T-27 after dry mixing and just before spreading and compacting. The Class of granular material to be used shall be as shown on the Drawings or otherwise as selected by the Engineer. The actual gradation shall, in all cases, be continuous and smooth within the specified limits for each Class. If gradation is tested after compaction, a tolerance of 3% is allowed in the upper limit for the percentage of material passing sieve no. 200.

Gradation of Granular Material by Class, shown table 13-1

Table 13-1: Gradation of Granular Material by class

Sieve Designation (Square openings)	Percent by weight passing	
	Class A	Class B
63 mm (2-1/2 in.)	100	
50 mm (2 in.)	80-100	100
37.5 mm (1-1/2 in.)	70-95	80-100
25 mm (1 in.)	55-90	60-95
12.5 mm (1/2 in.)	45-75	47-80
4.75 mm (No.4)	30-60	30-60
2.00 mm (No. 10)	22-48	22-45
0.425 mm (No.40)	10-30	10-30
0.075 mm (No. 200)	5-12	5-12

Sand equivalent

The material shall contain a minimum of **25%** sand equivalent at any stage of construction.

Loss weight of granular material

The loss weight of granular material shall not exceed **45%** after 500 revolution, when tested in accordance with AASHTO T 96 (Los Angeles Abrasion Test).

$$\text{The ratio of wear loss} = \frac{\text{Abrasion after 100 Rev.}}{\text{Abrasion after 500 Rev.}}$$

Should not be more than twenty percent of the maximum allowed abrasion after 500 revelations.

Soaked CBR

The granular material shall have a 4-day soaked CBR of not **less than 30** when compacted at 100% of modified proctor AASHTO (T 180-D) and tested in accordance with AASHTO T 193.

Soundness

When tested for soundness in accordance with AASHTO T 104, the material shall not show signs of disintegration and the percentage loss in weight after 5 cycles shall not exceed 12% in the case of the sodium sulphate test and 18% in the case of the magnesium sulphate test.

Portion of granular material

The portion of granular material, including any blended material, passing the 0.425 mm (No. 40) mesh sieve shall have a liquid limit (**L.L**) of **not more than 27** and a plasticity index (**P.I**) **not grater than 6** when tested in accordance with AASHTO T 89 and T 90.

Non-Plastic condition might be accepted if crushed limestone is used provided that angularity test (R) value shall not be less than 8.

Additional fine material

If additional fine material is required to correct the gradation of the granular material, or for adjusting the L.L. or P.I. of the fraction passing 0.425 mm (No. 40) sieve, it shall be uniformly blended and mixed with the granular material. Additional fine material for these purposes shall be

obtained from the crushing of stone, gravel, or slag, if naturally occurring fine materials not available.

11.3 Aggregate for Base Courses:

Aggregate for use in base course construction shall be crushed stone, and may be washed, if directed, to remove excessive quantities of clay, silty clay or salts.

It shall consist of hard durable and sound particles or fragments of stone, free from other substance. Other requirements are gypsum, or flaky particles.

Other requirements

Gypsum content (expressed as SO₃) 2 % max.

Clay lumps and friable particles 8 % max.

Elongated and flakey particles for crushed rock (Determined in accordance with BS 812 Part 1: 1975)

Granit and Basalt 40 % max each.

Lime stone 35 % max

Minimum dry density (g/cm³) 2.15 % min

Linear shrinkage not exceed 3%

Gradation of Base course Aggregate by class, shown in table 13-2.

Table 13-2: Gradation of Base course Aggregate by class

Sieve Designation	Percent by weight passing	
	Class A	Class B
50 mm (2 in)		100
37.5 mm (1.5 in)	100	70-100
25 mm (1 in)	75-100	55-85
19 mm (3/4 in)	60-90	50-80
12.5 mm (1/2 in)	45-80	
9.5 mm (3/8 in)	40-70	40-70
4.75 mm (No 4)	30-65	30-60
2 mm (No 10)	20-40	20-50
0.425 mm (No 40)	8-20	10-30
0.075 mm (No 200)	5-10	5-15

The material shall contain a minimum of 40% sand equivalent at any stage of construction.

The loss weight shall not exceed 40 % after 500 revolutions, when tested in accordance with AASHTO T96 (Los Angeles Abrasion Test).

The ratio of wear loss should not be more than twenty percent of maximum allowed abrasion after 500 revolutions.

The crushed aggregate base course material shall have a 4-day soaked CBR of not less than 80 when compacted at 100 % of modified proctor AASHTO (T 180-D) and tested in accordance with AASHTO T 193.

When tested for soundness in accordance with AASHTO -104, the material shall not show signs of disintegration and the loss by weight shall not exceed 12 % in case of the sodium sulphate test, and 18 % in the case of the magnesium sulphate test.

The portion of aggregate, including any blended material passing the 0.425 mm (No. 40) sieve shall have a liquid limit (L.L.) of not more than 25 and plasticity index (P.I) of not more than 6, and not less than 3 when tested in accordance with AASHTO T 89 and T 90.

If additional fine material is required to correct the aggregate gradation or for adjusting the L.L or P.I. of fraction passing the 0.425 mm (No 40) sieve, it shall be uniformly blended and mixed with the aggregate material.

Elongated and flakiness not to exceed 35% for each.

11.4 GRANULAR SUB-BASE COURSES

11.4.1 Scope

These Works shall consist of furnishing granular sub-base material of the required Class, mixing, spreading on prepared sub-grade, compacting and finishing, all as and where shown on the Drawings.

11.4.2 Materials

All materials shall conform to the relevant requirements of Section "Materials", in respect of granular material Class A or Class B for sub-base construction.

11.4.3 Sub-grade Surface Preparation

The sub-grade shall have previously been constructed in accordance with the requirements of Section "Sub-grade Construction and Topping" and properly maintained and kept well drained thereafter.

At all special grade control points, such as at bridge structures, existing pavements, etc. The sub-grade shall be lowered to a depth sufficient to permit construction of the sub-base course to the specified elevations and thickness.

Transitions shall be of sufficient length to avoid abrupt change of grade and shall be within plus or minus 3% of the final design grade unless otherwise directed. Surplus material shall be removed and disposed of.

The sub grade shall be inspected and approved immediately prior to commencement of sub-base construction. Any soft, yielding material shall be removed and replaced by approved topping material. Holes, depression and other irregularities shall be made good as directed and the sub-grade re-compacted as necessary and finished ready to receive the sub-base course.

11.4.4 Equipment

Equipment used to handle, place, spread, water, compact and finish sub-base shall conform to the requirements of Section "Contractor's Plant and Equipment" and with the Contractor's approved Work Program.

11.4.5 Construction

11.4.5.1 Stockpiling of Granular Material

Stockpiling procedures shall conform to the relevant requirements of Section "Materials".

Methods used for stockpiling granular material and removing it from stockpiles shall not result in significant degradation or segregation nor the introduction of significant amounts of foreign materials or extraneous matter.

Granular material adversely affected, in the opinion of the Engineer, by stockpiling or handling procedures shall be incorporated in the Works regardless of previous approval of such material, until the deficiencies have been rectified in an acceptable manner.

11.4.5.2 Mixing and Spreading

All components of sub-base course material shall be mixed thoroughly and uniformly with water in situ. The amount of water added, as approved by the Engineer, shall be such that the material will be uniform and within the specified moisture content range at the time of compaction. Wetting of granular material in stockpiles or in trucks before or during delivery to the Site will not be permitted. However, water shall be added to the material, if necessary, during placing and compaction of sub-base material.

The sub-base material shall be placed on the subgrade in a uniform two layers each 150 mm thickness (after compaction).

If approved, heavy duty vibratory compaction equipment is used, the sub base may be in one 300 mm layer (after compaction) provided compaction tests with appropriate testing equipment indicate that the specified compaction standard will be attained and uniform throughout the thickness.

The sub-base material shall be placed to the required width using a self-propelled spreader or motor grade equipped with blade extensions. Water shall be applied by approved spraying equipment and thoroughly mixed with the sub-base material.

The material shall not be bundled in such a way as to cause segregation. If the spreading equipment causes segregation in the material, or leaves ridges, or other objectionable marks on the surface which cannot be readily eliminated or prevented by adjustment of the equipment, the use of such equipment shall forthwith be discontinued and it shall be replaced by a spreader or grader capable of spreading the material in proper manner.

All segregated material shall be removed and replaced with well-graded material. "Skin" patching will not be permitted. Only minor surface manipulation and watering to achieve the required surface tolerances will be permitted during the compaction process.

Neither hauling nor placement of material will be permitted when, in the judgment of the Engineer, the weather or surface conditions are such that hauling operations will cause cutting of the subgrade or cause contamination of the sub-base material.

11.4.5.3 Compaction

The Contractor shall plan the sequence of operations so that the least amount of water will be lost by evaporation from uncompleted surfaces, If the Contractor delays placing of succeeding layers of material to the extent that additional water is required to prevent raveling or excessive drying, the application of such water shall be carried out as directed and at the Contractor's expense.

The sub-base material shall be compacted by means of approved compaction equipment, progressing gradually from the outside towards the center, with each succeeding pass uniformly overlapping the previous pass.

Rolling shall continue until the entire thickness of each sub-base layer so thoroughly and uniformly

to 100% AASHTO T 180 (Method D) maximum density. Final rolling of the completed course shall be by means of an approved self-propelled roller. Rolling shall be accompanied by sufficient blading, to insure a smooth surface, free from ruts or ridges and having the proper shape. When additional water is required, it shall be applied in an approved manner.

Any areas inaccessible to normal compaction shall be compacted by use of portable mechanical tampers until the required standard of compaction is achieved.

Each layer shall be completely compacted and approved prior to delivery of materials for the subsequent layer.

Prior to placing a subsequent layer, the existing surface shall be made sufficiently moist as directed, to ensure proper bond between the layers.

The edges and slopes of the sub-base course shall be bladed or otherwise dressed to conform to the lines and dimensions shown on the Drawings and to present straight, neat lines and slopes as free of loose material as practicable.

Material which has dried out prior to final compaction, or which has dried and compacted subsequent to final compaction, shall be watered and recompactd using approved equipment and procedure. If the Contractor is unable to return the material to its original or specified condition with respect to compaction, thickness and surface tolerances, the Contractor shall remove the material and reconstruct the sub-base course on a re-approved sub grade.

11.4.5.4 Tolerances

The fully compacted and completed sub-base course shall conform to the lines, grades and cross sections as shown on the Drawings.

The elevations of the finished sub-base course shall be checked by the Contractor in the presence of the Engineer at maximum intervals of 10 m and at intermediate points as directed.

The tolerance on elevations of finished surface shall be plus 10 mm to minus 20 mm, minus tolerance shall be compensating by the proceeding layer.

When the finished surface is tested with a 3 m long straightedge, placed parallel to, or at right angles to the centerline, the maximum deviation of the surface from the testing edge between any 2 contact points shall not exceed 10 mm.

All areas which exceed the specified tolerances shall be corrected by removing the defective sections of sub-base and reconstructing them or, if approved, by adding new material mixing and re-compacting and finishing to the specified standard.

11.4.5.5 Maintenance of Completed Sub-base

Following completion and acceptance of the sub-base course, it shall be maintained by the Contractor at his own expense. The sub-base shall be bladed, broomed and otherwise maintained, keeping it free from raveling and other defects until such time as the base course is placed. Water shall be applied at such times and in such directed by the Engineer.

11.4.6 Testing

Every 500 linear meter of sub-base material or whenever there is a change in the material source

shall be subject to a full set of tests after mixing in situ and, if found satisfactory, shall be approved for compaction. This approval shall not deem to constitute acceptance of the sub-base course.

Sampling and testing shall conform to the relevant requirements of Section 1.05- "Control of Materials and Standards for Sampling and Testing".

Compaction shall be tested in accordance with AASHTO T 191 or AASHTO T 205. If there is a delay between the construction of any layer and the following layer, if necessary and required by the Engineer the compaction of the lower layer may be recertified to ensure that it has not loosened due to traffic, passage of construction equipment, adverse weather conditions or otherwise.

11.5 AGGREGATE BASE COURSES

11.5.1 Scope

These works shall consist of furnishing crushed aggregate base course material of class a, mixing, spreading, compacting and finishing, all as and where shown in the Drawings.

11.5.2 Surface Preparation

The sub-grade surface shall be inspected and approved prior to commencement of base construction, Holes, depressions and other irregularities shall be made good as directed an the sub-grade re-compacted as necessary and finished ready to receive the base course layer.

11.5.3 Equipment

Equipment used to handle, place, spread, water, compact and finish base course in accordance with contractor's Work program approved by the Engineer.

11.5.4 Construction

11.5.4.1 Stockpiling of Base Course Material

Stockpiling method of aggregates and moving them from stockpiles shall not result in significant degradation or the introduction of significant amounts of foreign materials. Aggregate materials adversely affected, in the opinion of the Engineer, by stockpiling or handling procedures shall not be incorporated in the works regardless of previous approval of such material until the deficiencies have been rectified in an acceptable manner.

11.5.4.2 Mixing and Spreading

Base course material shall be mixed with water to reach the specified moisture content range at the time of compaction. The mixed material shall be handled and placed on subgrade in a uniform layer as to not cause segregation. All segregating material shall be removed and replaced with well-graded material, "Skin" patching will not be permitted and spread to the required width and shall be delivered such that it is ready for compaction without farther shaping.

11.5.4.3 Compaction

The contractor shall plan the sequence of operations so that the least amount of water will be lost by evaporation from uncompleted surfaces.

The base course material shall be compacted by means of approved compaction equipment,

progressing gradually from the outside towards the center, with each succeeding pass uniformly overlapping the previous pass. Rolling shall continue until the entire thickness of each base layer is thoroughly and uniformly compacted to 100% AASHTO T 180 (Method D) maximum density:

The edges and edge slopes of the base course shall be bladed or otherwise dressed to conform to the lines and dimension shown on the Drawings.

Materials which have dried out prior to final compaction, or which has dried and decompacted subsequent to final compaction, shall be watered and recompactd. If the contractor failed to return the material to its original or specified condition with respect to compaction, thickness and surface tolerance the contractor shall scarify the material and reconstruct the base course on a re-approved subgrade surface or to the satisfaction of the Engineer.

11.5.4.4 Tolerances

The dully-compacted base course shall conform to the lines, grades and cross sections as shown in the drawings.

The elevations of base course shall be checked at intervals of 20 m on straight and 10 m on curves, the tolerance on elevations of surface shall not exceed +10 mm or -05 mm, and not exceed 12 mm between any two contact points tested with a 4 m long straight edge placed parallel to, or at right angles to center line.

All areas which exceed the specified tolerances shall be scarified and corrected to specified standard.

11.5.4.5 Maintenance of Completed Base Course

Following completion and acceptance of base course, it shall be maintained by contractor at his own expense. The surface shall be broomed and rolled keeping it free from defects until such time as the following course is placed. Water shall be applied at such times and in such quantities as directed.

11.5.5 Testing

Sub base and base Course material shall be tested in accordance with the table shown below at stock pile and at the mixing plant for control on site tests, and if satisfactory shall be approved for use. This approval shall not be deemed to constitute acceptance of base course for full payment purposes.

Required Tests and Minimum Repetition for Base course material, shown in table 13-3.

Table 13-3: Required Tests and Minimum Repetition for Base course

Source of Materials		Control on Site (The Road)	
Required Test	Repetition Required for all Test	Required Tests	Repetition Required for all Test
1-Gradation of materials	* Test for each source	1. Proctor	* test for every 500 Lm for each layer * when materials changed
2- Plasticity Index	* for every 1000 m ³	2. Gradation of materials	
3- Abrasion	* When materials changed or every 1000 m ³	3. Plasticity Index	

4- C.B.R.		4. C.B.R.	
5- Sand equivalent		5. Abrasion	
6-Percentage of Fractured Grains		6. Sand equivalent 7. Clay Lumps & Friable particles 8. Field Density 9. Thickness	

Compaction test: for every layer at least 3 samples taken for one street or 1000 m² from layer area, or 200 linear meter of road which is smaller.

11.5.6 Measurement

1. The net area executed must be measured (without the area under the curb stone).
2. The area of manholes and gullies is to be deducted from measurement.

12 -BITUMINOUS CONSTRUCTION

12.1 Material

12.1.1 Scope

All material sources and the quality of materials proposed for use in the works shall be approved prior to procurement or processing material from such sources. Inspection, sampling, testing and re-testing as necessary, shall be at the contractors expense.

12.1.2 Sampling and Testing of Aggregate

In order to ascertain the properties of aggregate materials, the contractor shall submit for testing and approval, representative samples of all materials intended for corporation in the works, prior to starting quarry operations, the samples shall be taken by contractor in the presence of the Engineer.

Tests performed by the contractor shall utilize in assessing the locations, extent of deposits and quantities of materials which will conform to the specifications when properly processed. All testing as carried out by the contractor shall in no way obviate the need for further testing by Engineer.

Approval of specific sources of materials shall not be considered as final approval and acceptance of materials from such sources.

Unsatisfactory materials whether in place or not, shall be removed promptly from the site. The contractor shall furnish all necessary material, labor, tools, and equipment and transport required by the engineer for such inspections.

12.1.3 Aggregates for Bituminous Paving Mixes

1. Aggregate for use in bituminous, binder and wearing courses, shall consist of crushed stone.
2. Course aggregate shall be the fraction of crushed aggregate material retained on 4.75 mm (No. 4) sieve. Fine aggregate shall be the fraction of crushed aggregate material passing 4.75 mm (No. 4) sieve. Mineral filler shall be added when the combined grading of course and fine aggregates is deficient in material passing 0.075 mm (No. 200) sieve.
3. The material from hot bins passing the number 40 sieve (0.425 mm) when tested in accordance with AASHTO T90 shall be non plastic.
4. Aggregate shall not contain gypsum more than 1% and the course fraction of the aggregate shall not contain more than:
 - 5% chert and flint for aggregate to be used in the Wearing course.
 - 5% chert and flint for aggregate to be used in the Binder course.
5. Aggregates shall be of uniform quality, free from decomposed stone, organic matter, shale.
6. The percentage by weight of friable particles, clay lumps, and other deleterious matter shall not exceed 1% as determined by AASHTO T112.
7. Aggregate particles shall be clean, hard, durable and sound. Crushing shall result in a product such that, for particles retained on 4.75 mm (No. 4) sieve, at least 90% by weight shall have 2 or more fractured faces.

8. The flakiness index and the elongation index test should be conducted in accordance with BS 812, the flakiness and elongation index must be less than 30.
9. Aggregates shall be washed if directed, to remove any clay lumps, organic matter, adherent dust or clay films or other extraneous or deleterious matter that may prevent or detract from proper adhesion of bitumen to the aggregate particles.
10. Material filler shall consist of finely divided mineral matter such as limestone dust if added separately; hydrated lime; other non-plastic mineral filler, free from clay and organic impurities; or Portland cement, conforming to AASHTO M17.
11. Combined course and fine aggregates for bituminous mixes, including mineral filler, when tested in accordance with AASHTO T27 and T11, shall conform to gradations shown in Table shown below (Table 14-1):-

Table 14-1: Gradation of Aggregates for Bituminous Mixes

Sieve Designation	Binder Course Percent Passing	Wearing Course Percent Passing
1" (25.0mm)	-	-
3/4" (19.0mm)	100	100
1/2" (12.5mm)	82±9	89±9
3/8" (9.5 mm)	72±9	82±9
No. 4 (4.75mm)	54±9	66±9
No. 8 (2.36mm)	41±9	53±9
No. 16 (1.18mm)	32±9	41±9
No. 30 (0.600mm)	24±9	31±9
No. 50 (0.300mm)	17±7	21±8
No. 80 (0.150mm)	12±5	13±6
No. 200 (0.75mm)	5±2	4.5±2.5

12. The loss in weight of aggregate after 500 revolutions, when tested in accordance with AASHTO T96, shall not exceed 35%.

Ratio of wear loss =

is less than or equal 25.

13. When tested for soundness in accordance with AASHTO T104 the course aggregate (retained on No. 4 sieve) shall not shown sings of disintegration and the loss by weight after 5 cycles shall not exceed 9% in the case of the sodium sulphate test and 12% in the case of the magnesium sulphate test.
14. When tested for resistance to stripping in accordance with the AASHTO T-182 at least 95% coated particles should be achieved. Scandinavian test shall be carried out and at last 60% of the coarse aggregate surfaces area shall remain coated with a bitumen film especially for exposed surfaces other wise anti stripping agent must be added to achieve the required coating.
15. The material shall contain minimum 50% sand equivalent. Test sample shall be taken from hot bins.
16. Minimum Dry Specific Gravity (g/cm³) 2.55 min
17. Water absorption not exceed 2%

12.1.4 Heating of Bitumen

1. Heating equipment shall be of an approved type. Any method of heating that introduces free steam or moisture into the bitumen will not be approved.
2. Bitumen shall not be heated more than 170degrees C. materials heated in excess of this temperature will be rejected and shall not be used in the works.
3. Heating of bitumen shall be uniform and under control at all times, to the specified temperature. The circulation system shall be of adequate size to insure proper and continuous circulation of bitumen during the entire operating period.
4. Thermometers of adequate range (calibrated in 2 degrees c increments) for accurately measuring the temperature of the bitumen, shall be located so as to be readily visible and shall be kept clean and working order at all times.

12.2 BITUMINOUS PRIME AND TACK COATS

12.2.1 Scope

This work shall consist of furnishing and applying and MC cutback bitumen prime coat to a previously constructed aggregate base course and applying tack coat on Asphalt or concrete surfaces all as and where shown on the Drawings.

12.2.2 Medium Curing Cutback Bitumen

1. MC-70 cutback bitumen for prime coat shall be used as recommended by ASTM D2399-83 for open and tight surface, and RC-70 should be used as tack coat.
2. All surfaces to receive either prime or tack coats shall conform to the specified tolerances and compaction requirements and shall be properly cleaned and finally approved before applying any bitumen material.
3. Application of prime and tack coats shall be performed only when the surface to be treated is sufficiently moist and atmospheric temperature is above 15 C. There should be no fog, rain, strong winds, dusty conditions, or dust storms.
4. The surface of all structures shall be protected in an approved manner during the equipment operation. The contractor shall be responsible for making good any staining or damage of the structures to the satisfaction of the Engineer.
5. Traffic shall not be permitted to surfaces after they have been cleaned and prepared for prime coat application.
6. The contractor shall maintain prime or tack coats until it is covered by the subsequent pavement course.
7. Any area where the coats have been damaged shall be cleaned of all loose material and re-applied at the contractor's expense.
8. Applying temperature of MC- 70 shall be 45-80C.
9. Areas to be primed shall be including 200 mm widths outside the edge of the permanent line.

10. Application rate for prime coat shall be 1 lit/sq.m and tack coat application shall be 0.7 lit/sq.m.
11. Asphalt pavement shall not be placed on prime coat before 24 hours, and no traffic is allowed to pass on prime coat.
12. The minimum solid residue by evaporation by weight must exceed 50 % when tested according to ASTM D 1461-85.
13. The Ash content of residue by weight must not exceed 7 % when tested according to AASHTO T-83(2000).
14. The drying time for prime coat must not exceed 24 hour.
15. The density range from 990 to 1010 gm/l when tested according to ASTM D 70

12.3 BITUMINOUS COURSES

12.3.1 Scope

This work shall consist of the general requirements of furnishing materials, mixing at a central mixing plant, spreading and compacting bituminous courses.

12.3.2 Job Mix and Project Mixes

1. The contractor shall submit certificate of origin of all material used in the mix for approval of the engineer, the material must be of best kinds.
2. The contractor shall submit his proposed Job Mix Formula for approval, at least 30 days prior to beginning production so that the life of the submitted Job Mix should not exceed 6 months from the date of submission for small size projects but to be furnished particularly for large size projects . Therefore, samples from materials use in the preparing mix design (aggregates and bitumen) shall be sent to specialized laboratories to be tested for final approval of mix design.
3. The Job Mix Formula is established by the contractor, under the supervision of the engineer, in the field laboratory mix design procedures shall conform to the Marshall method of mix design. All trial mixes shall be prepared and tested by the contractor in the presence of the Engineer.
4. The Job Mix Formula shall specify a combination of mineral aggregates including filler and bitumen in such proportions as to produce a Job Mix which is within the limits of the specified gradation and bitumen content ranges and which meets the Marshall Test requirements. It shall also stipulate the mixing temperature at discharge from the mixer which, unless otherwise directed, shall be 170 degrees C.
5. The Marshall Test procedure shall be used to determine the percentage of bitumen to be incorporated in the mix. The Job Mix Formula shall take into consideration the absorption of bitumen into the aggregates. Air voids shall be calculated in accordance with the procedure given in the Asphalt Institute Manual, MS-2.
6. When compacting specimens on accordance with the Marshall Test procedure, the number of blows applied with the compaction hammer shall be 75 on each side.
7. In order to meet the requirements, an approved additive such as Portland cement, hydrated lime or liquid antistrip agent, may be required in the Job Mix. Portland cement shall meet the

requirements of ASTM M 85. Hydrated lime shall meet the requirements of ASTM C207, Type N. Cement or hydrated lime will normally be required in the approximate range of 2-3% by weight of the aggregates and shall be added at the cold feed in dry or slurry form as directed. Liquid antistripping agent, if needed will normally be required in the approximate range of 0.6-1.0% by weight of the bitumen, or according to the manufacturers specifications.

8. Upon receipt of approval of the Job Mix Formula, the Contractor shall adjust his mixing plant to proportion the individual aggregates, mineral filler and bitumen to produce a final project mix within the limits given in Table shown (14-2) with respect to the Job Mix gradation

Table 14-2: Maximum Variations of Project Mix from Approved Job Mix

Sieve Designation (square openings)	Specified Tolerances
9.5 mm (3/8 in.) and above	± 5.0%
4.75 mm (No. 4)	± 4.0%
2.36 mm (No. 8)	± 4.0%
1.18 mm (No. 16)	± 4.0%
0.600 mm (No. 30)	± 4.0%
0.300 mm (No. 50)	± 4.0%
0.150 mm (No. 100)	± 4.0%
0.75 mm (No. 200)	± 1.5%
Bitumen Content	± 0.3%
Temperature of Mix on discharge temperature	± 5 C of the specified mixing

9. Conformance to gradation requirements will be determined on the extracted aggregate in accordance with AASHTO T 30. The bitumen content shall be determined in accordance with AASHTO T 164.
10. The participation of the Engineer in the preparation of the Job Mix Formula shall in no way relieve the Contractor of responsibility for producing project mixes meeting the specified requirements.

12.3.3 Spreading and Finishing Equipment

1. Bituminous course shall be spread and finished using approved type, self contained, power-propelled pavers of sufficient capacity. Pavers shall be provided with electronically controlled vibratory screed or strike-off assembly and shall be capable of spreading and finishing the course of bituminous mix to the proper thickness and in lane widths applicable to the typical cross sections shown on the Drawings.
2. The pavers shall employ mechanical devices such as equalizing runners, straightedge runners, eveners or other compensating devices, to maintain trueness of grade and confine the edges of the mix to true lines without the use of stationary side forms. Joint leveling devices shall be provided for smoothing adjusting longitudinal joints between lanes.
3. The paver shall be equipped with receiving hopper having sufficient capacity for a uniform spreading operation. The hopper is equipped with a distribution system to place the mix uniformly in front of the full length of the screed.
4. The screed or strike-off assembly and extensions shall effectively produce a finished surface of

the required evenness and texture without tearing, shoving, or gouging the mix.

5. The paver shall be capable of being operated at forward speeds consistent with satisfactory laying of the mix. Speed shall be fully adjustable
6. The Contractor shall make available, for reference by the engineer, the manufacturer's instruction and operating manuals for each paver intended for use.

12.3.4 Surface Preparation

1. When the bituminous mix is to be placed on a base course, the surface shall be prepared to meet the appropriate specified compaction and surface tolerance requirements. The surface shall then be primed as specified "Bituminous Prime Coat". No bituminous mix shall be laid on a prime coat until it has been inspected and approved.
2. Broken, soft, or unstable areas of aggregate base course shall be removed and replaced. The areas shall be excavated to a depth as directed and refilled with the specified bituminous mix.

12.3.5 Delivery, Spreading and Finishing

12.3.5.1 Delivery of Mix to Site

1. A sufficient number of haul vehicles shall be provided so that adequate supplies of mix are delivered to ensure that continuous paving will be achieved.
2. Hauling equipment for aggregates and bituminous mixes shall consist of vehicles having dump bodies suitable for dumping materials in a windrow or in spreader boxes. The bodies shall be so constructed that their volume measurement can be accurately determined. They shall be constructed and maintained such that loss of materials during hauling operations will not occur.
3. Dump controls shall be capable of operation from the driver's seat.
4. Hauling equipment for hot bituminous mixes shall have tight, clean, smooth metal beds which are periodically thinly coated with a lime solution or other approved material to prevent adherence of the mix. All hauling units shall be equipped with a canvas or other approved type cover which shall be used to cover the hot material upon loading at the mixing plant and shall not be removed until the mix is discharged into the paver.
5. The dispatching of the hauling vehicles to the site shall be so scheduled that all material delivered is placed at least 90 minutes before sunset to allow sufficient time for compaction.
6. Delivery of material shall be at a uniform rate and in an amount well within the capacity of the paving and compacting equipment.
7. The mix delivered to site must have a temperature range from 139° to 163°.
8. Each haul vehicle shall be weighed after each loading at the mixing plant and accurate records shall be kept of the gross weight and net weight of each load, for each vehicle dates and time of loading.

12.3.5.2 Setting out Reference Line

1. The Contractor shall survey the centerline profile and crown of the existing surface or base and determine a reference grade line which will be submitted for approval. A reference line of wire or suitable cord shall be installed at a uniform grade parallel to the approved reference grade

line such that conformance with the required geometrics, surface tolerance and minimum thickness requirements shall be ensured.

2. The reference line shall be maintained taut and free from sags at all times during spreading and initial compacting operations.
3. A wire or cord reference line shall be installed on both sides of the paver for the initial bituminous course being laid. Thereafter only one reference line will normally be required, if the paver is equipped with adequate automatic super elevation control.

12.3.5.3 Spreading and Finishing

1. Bituminous mixes shall be laid only when the air temperature is at least 5 degrees C or above when the existing surface is free from moisture, and when the weather is not foggy, rainy, dusty or excessively windy (particularly at low temperatures).
2. After completion of surface preparation, the bituminous mix shall be spread and finished true to crown and grade by approved automatically controlled bituminous pavers. The mix may be spread and finished by approved hand methods only where the engineer determines that machine methods are impracticable. Hand methods include heated hand tampers of at least 10 kg weight and approved type mechanical (vibratory) tampers.
3. The paver shall spread the bituminous mix without tearing the surface and shall strike a finish that is smooth, true to cross section, uniform in density and texture and free from hollows, transverse corrugations and other irregularities.
4. The paver shall be operated at a speed which gives the best results for the type of pavers being used and which coordinates satisfactorily with the rate of delivery of the mix to the paver. A uniform rate of placement shall be achieved without repeated intermittent operation of the paver.
5. The mix shall be delivered to the paver in time to permit completion of spreading, finishing and compaction of the mix during daylight hours.
6. If during laying, the paver is repeatedly delayed because of lack of mix or if the paver stands at one location for an extended period, resulting in the (unrolled) mat under and adjacent to the rear of the spreader falling below the minimum temperature for breakdown rolling, the affected portion of mat shall be cut out and discarded and a transverse joint shall be constructed. Paving shall not recommence until the engineer is satisfied that paving will proceed without interruptions.
7. Contact surfaces of curbing, gutters, manholes, and similar structures shall be painted with a thin, uniform coating of tack coat material. The bituminous mixture shall be placed uniformly high near the contact surfaces so that after compaction it will be 10 mm above the edge of such structure.
8. If during the paving operations, it is found that the spreading and finishing equipment in operation leaves in the pavement surface tracks or indented areas or other objectionable irregularities that are not satisfactorily corrected by the scheduled operations, the use of the equipment shall be discontinued, until faults are corrected to the approval of the engineer. If this is not possible, other satisfactory spreading and finishing equipment shall be provided by the contractor.

9. Transverse joints in succeeding layers shall be offset by at least 2 m. Longitudinal joints shall be offset at least 150 mm.
10. Bituminous mix shall be spread in one or more layers so that, after rolling, the nominal thickness of each layer of the compacted bituminous material does not exceed 2 to 3 times maximum size of aggregate. This maximum thickness may be increased slightly when such increase is more appropriate to total pavement thickness and provided the engineer determines that such increased thickness will not be detrimental to the quality of the finished bituminous course, and the contractor can show that the required density is attained throughout the layer thickness.
11. Transitions and structure approaches shall meet the design criteria for geometrics, the surface tolerance specifications, and shall not be visually discontinuous or abrupt in appearance.

12.3.5.4 Joints and Edges

1. All joints between old and new pavements or between successive days' work shall be as to ensure thorough and continuous bond between the old and new material.
2. Before placing fresh mix against previously laid, the contact surface shall be cut back to a near vertical face, and shall be sprayed or painted with a thin uniform coat of tack coat material. Longitudinal joints shall be made by overlapping the paver screed on the previously laid material (cut back as necessary) and depositing a sufficient amount of fresh mix so that the joint formed will be smooth and tight.
3. Unsupported edges of bituminous layers shall be rolled immediately following the rolling of the longitudinal joint. The material along the unsupported edge may, if approved, be raised slightly by hand methods, to ensure that the full weight of the roller will bear fully on the edge material.
4. On completion, the longitudinal edges of bituminous pavement shall be true to the width and alignment as shown on the drawings. The edges shall be cut back if necessary prior to rolling, additional mix placed manually in a longitudinal strip adjoining each pavement edge, and the edge rolled down to a neat 3:1 (H:V) slope.
5. Transverse joints shall be carefully constructed and thoroughly compacted to provide a smooth riding surface. Joints shall be straight-edged and string-lined to assure smoothness and true alignment.

12.3.5.5 Compaction

1. After spreading and strike-off, and as soon as the mix conditions permit the rolling to be performed without excessive shoving or tearing, the mixture shall be thoroughly and uniformly compacted, using approved types, sizes and number of rollers. Rolling shall not be prolonged to the point where cracks appear or shoving or displacement occurs.
2. All rollers shall be self-propelled vibratory steel wheel, 2-axle tandem steel-tired and pneumatic-tired types, in proper operating condition, capable of reversing without backlash or tearing of the surface, and shall be operated at numbers of rollers required is 3, of which one must be pneumatic type. The Contractor shall select a suitable method and pattern of rolling that will achieve the required compaction, to engineers approval.
3. Prior to use on site of pneumatic-tired rollers, the contractor shall furnish, for reference and retention by the engineer, manufacturers' charts or tabulations showing the contact areas and

contact pressures for the full range of tire inflation pressures and for the full range of tire loadings for each type and size of compactor tire to be used. The contractor shall ensure that tire pressures are maintained at all times in conformity with such charts or tabulations. The maximum allowable tolerances shall be plus or minus 35 KN/sq.m (5 psi).

4. Rollers should move at a slow but uniform speed, generally with the drive roll or wheels nearest the paver.
5. Breakdown rolling shall be consist of 3 complete coverage unless otherwise directed. Rolling shall be longitudinal, and overlapping on successive trips by at least one half the width of the rear wheels.
6. To prevent adhesion of the mix to the rollers, the wheels shall be kept lightly moistened with water. Excessive use of water will not be permitted.
7. The initial or breakdown rolling shall be followed by intermediate rolling involving 3 coverage with pneumatic-tired rollers unless otherwise specified.
8. Finishing rolling shall then be carried out by means of tandem power steel rollers unless otherwise designated. If specified density is not achieved, changes shall be made in size and number of rollers being used to ensure the compaction requirements are met.
9. The compacted density shall be equal to or more than 97% and 98% for binder course and wearing course, respectively, of average Marshall bulk specific gravity for each day production unless otherwise directed by the engineer.
10. If after re-testing the density achieved is 0.5% or less below the specified density, the asphaltic layer will be accepted in the works subject to a 10% reduction to the billed rates. If on the other hand the density achieved is greater than 0.5% below the specified density the asphaltic material shall be removed and new materials laid to the specification at the contractor's cost.

12.3.5.6 Test for Bituminous Pavements

1. Minimum Tests Required as shown in table 14-3 below:

Table 14-3: Minimum Test Required for Bituminous

Work item	Tests at Source of material	Frequency of tests	Tests at road site	Frequency of tests
1- Materials used in Asphalt mix (at Batching plant)	1- Specific gravity and water absorption 2- Abrasion test 3- Chert content 4- Clay lumps and friable materials 5- Flaky and elongated particles	- Test for each source - When materials quality changes - As requested		

Work item	Tests at Source of material	Frequency of tests	Tests at road site	Frequency of tests
	6- Soundness			
2- Materials used in Asphalt mix (from hot bins)	1- Gradation 2- Specific gravity and water absorption 3- Plasticity index 4-Sand equivalent 5- Stripping with asphalt	- Test for each source - when materials quality changes - As requested		
3- Asphalt mix design (At batching plant)	1. Complete mix design in accordance with American Asphalt Institute (MS2) 2. Loss of stability	-For each project -When materials quality changes -When results are not consistent with the mix design results - As requested		
4- Asphalt	At Batching plant 1- Stability 2- Flow 3- Extraction (binder content and gradation) 4- Air voids 5- Voids in mineral aggregates 6- Daily Marshall density	- Test each 3 working days - Test for each batching plant - As requested	Behind spreader 1- Stability 2- Flow 3-Extraction (binder content and gradation 4-Air voids 5- Voids in mineral aggregates 6-Marshall density	-Test each working day - Test for each batch - As requested
	7-Loss of Stability	- Once a week - As requested	7- Road density and thickness (after final compaction	- Test each 200 lin.m. per lane - As requested
			8-Loss off stability	- Once a week - As requested

- The Marshall Bulk specific gravity shall be determined in accordance with AASHTO T 166 or AASHTO T 275. The Marshall specimens shall be prepared from the same material used in construction, taken from samples of fresh bituminous mix at the mixing plant or from trucks delivering mix to the site. Oven heating for up to 30 minutes to maintain the heat of the sample is permissible.

3. The bulk specific gravity of the mix as placed and compacted in situ shall be determined from 100 mm nominal diameter core samples, or slab samples cut from compacted layer on the road at locations designated by the engineer who may require additional tests to determine limits of areas deficient in density, or for recheck.
4. Samples for in situ bulk specific gravity determinations shall be taken in sets of 2 from each pavement location. Minimum frequency of sampling for each bituminous layer shall be one set/lane/500 m, with a minimum of one set per day of placing bituminous layers.
5. The contractor shall, cut the samples with an approved core drill in the presence of the engineer. The equipment shall be capable of cutting the mixture without shattering the edges or otherwise disturbing the density of the specimen. The contractor shall fill and compact all test holes at his own expense.

12.3.6 Surface Tolerances

1. The fully compacted and completed bituminous course shall conform to the lines, grades and cross sections as shown on the drawings.
2. The elevations of the finished course shall be checked by the contractor in the presence of the engineer at maximum intervals of 25m and at intermediate points as directed.
3. When the finished surface is tested with a 4 m long straightedge, placed parallel to, or at right angles to the centerline, the maximum deviation of the surface from the test edge between any 2 contacts points shall not exceed the tolerances specified 6.0 mm.
4. All areas which exceed the specified tolerances shall be corrected by removing the defective sections of bituminous course and reconstructing them or, if approved, by adding new material and recompacting and finishing to the specified standard or increasing the thickness of the succeeding course.
5. The tolerances specified for evenness of finished surfaces for all types of bituminous course, shall not invalidate the tolerances specified for construction thickness and elevations of such courses.

12.3.7 Determination of Thickness of Course

1. Cylinder core samples shall be taken as specified for in situ bulk specified gravity core samples.
2. Thickness of bituminous course shall be determined by average caliper measurement of cores, rounded upwards to the nearest mm.
3. Paved sections to be measured separately shall consist of each 200 lin.m section in each traffic lane. The last section in each traffic lane shall be 200 m plus the fractional part of 200 m remaining. Other areas such as intersections, entrances, etc. shall be measured as one section and the thickness of each shall be determined separately. Small irregular unit areas may be included as part of another section.
4. One core shall be taken from each section by the contractor at approved location and in the presence of the engineer. When the measurement of the core from any paved section is not deficient by more than 3 mm from the specified thickness, the core will be deemed to be off the specified thickness as shown on the drawings.

5. When the measurement of the core from any paved section is deficient by more than 3 mm but not more than 15% from specified thickness layer, 2 additional cores spaced at not less than 100 m shall be taken and used together with the first core to determine the average thickness of such section, if it failed again, 15% will reduction from unit price.
6. When the measurement of the core from any paved section is less than the specified thickness by more than 15% from specified thickness layer, the average thickness of such section shall be determined by taking additional cores at not less than 5 m intervals parallel to the centerline in each direction from the affected location until, in each direction, a core is taken which is not deficient by more than 15% from specified thickness layer, Exploratory cores for deficient thickness will not be used in average thickness determinations, if it failed again, Asphalt layer will remove or replacement.
7. Any deficiencies in the total thickness of bituminous courses shall be subject to a proportional reduction in the area of (wearing) course measured for payment. Alternatively, the contractor shall construct all at his own expense, a wearing course overlay, if practicable in the judgment of the engineer. Any such overlay shall be a minimum of 30 mm compacted thicknesses and to the specified standard of the course it is overlaying.
8. If the deficiency in total asphalt layers thickness is from 0 -3 mm, full payment will be made, on condition that deficiencies are not found in more than 10% of the total project. Deficiencies exceeding 3 mm shall be left to the substantial handing -over procedure.

12.3.8 Measurement

1. Bituminous course shall be measured by sq.m for furnished, paved compacted, tested and approved areas placed according to drawing.
2. Any correction, tests, samples, etc. shall not be measured for direct payment.

12.4 BITUMINOUS BINDER AND WEARING COURSES

12.4.1 Scope

These works shall consist of furnishing materials, mixing at mixing plant, spreading and compacting bituminous binder and wearing course on an approved aggregate base course as and where shown in the drawings.

12.4.2 Materials

1. Materials shall conform to relevant requirements of section” Materials” mentioned before.
2. Unless otherwise shown on drawings, bitumen for binder and wearing course construction shall be 60/70 penetration graded bitumen.

12.4.3 Job Mix and Project Mix

1. The Job Mix formula shall be established by the contractor in accordance with the procedure and requirements of section “Bituminous Course” mentioned before.
2. The Job Mix for bituminous binder and wearing courses shall conform to the following composition limits, as shown in Table 14-4:

Table 14-4: Job Mix Requirements to Bituminous Courses

Property Medium-Light		
	<i>Binder</i>	<i>Wearing</i>
Marshall Stability at 60c (kg)	900	900
Flow (mms)	2-4	2-4
Voids in Mineral aggregate %	13.5	14.5
Voids in total mix (%)	3-7	3-5
Stiffness (kg/mm)	500 (Min)	400 (Min)
* Loss of stability (%)	25(Max)	25(Max)
Asphalt Content (% in weight)	4.5-6	5-7

* This test to be carried out in accordance with AASHTO T 165-82.

* After the Job Mix Formula has been established and approved, all subsequent mixes shall conform to it within the allowable tolerances.

12.4.4 Equipment

Plant and equipment for mixing, hauling, placing and compacting bituminous binder course and wearing course materials, shall conform to the relevant requirements of section “Bituminous Course”.

12.4.5 Surface Preparation:

Preparation of surface upon which bituminous binder course and the bituminous wearing course mixes are to be laid, and the use of prime coat, shall be appropriate to type and condition of such surface and shall conform with the relevant requirements of section "Bituminous Courses".

12.4.6 Delivery, Spreading and Finishing

12.4.6.1 General

The delivery, spreading and finishing of bituminous mixes for binder and wearing courses shall conform with the relevant requirements of Section “Bituminous Course” and to the following particular requirements.

12.4.6.2 Rollers

1. Initial breakdown rolling shall be carried out by use of 2 dual-drum steel-wheeled rollers each of minimum weight 7,000 kg. These rollers shall be purpose made for compaction of hot bituminous courses.
2. Intermediate rolling shall be carried out by of at least 2 self-propelled, tandem pneumatic smooth-tired rollers each capable of exerting contact pressures of up to 690 kN/sq.m (100 psi) and ballast- adjustable to ensure uniform wheel loadings.
3. Final rolling shall be carried out by use 2, 2-axle tandem, steel-tired rollers each of minimum weight 10.000 kg, capable of exerting contract pressures of up to 65 kg/cm (350 lb/in.)

12.4.6.3 Standard of Compaction

The compacted density of the bituminous wearing course shall be not less than 98% of the average Marshall Bulk density for each day's production.

12.4.7 Sampling and Testing

Sampling and testing shall conform to the relevant requirements of Section "Bituminous Course".

12.4.8 Surface Tolerances

1. Surface tolerances shall conform with the relevant requirements of Section "Bituminous Course", and to the following particular requirements.
2. The tolerances on elevations of the final bituminous wearing course surface shall not be greater than 10 mms.
3. When the finished wearing course surface is tested with a 3 m long straightedge, placed parallel to, or at right angles to the centerline, the maximum deviation of the surface from the testing edge between any 2 contact points shall not exceed 5.0 mm.

12.4.9 Determination of Thickness

1. Procedures for determining the average compacted thickness of bituminous binder and wearing course shall conform with the relevant requirements of Section "Bituminous Courses" and the following particular requirements.
2. Cores for thickness measurements of binder course shall be used to determine if changes are necessary in the constructed thickness of the wearing course to rectify and thickness deficiencies in the binder course.

12.4.10 Measurement

1. Bituminous binder course and bituminous wearing course shall be measured by sq.m. of mix finished, spread, compacted, completed and accepted; measurements shall be of the areas and thickness as shown on the drawings.
2. Deficiencies in thickness of wearing course shall, unless an overlay is constructed at contractor's expense, result in proportion only of the wearing course area being measured for payment. Proportions shall be determined in accordance with the thickness deficiencies and area proportions mentioned in section "Bituminous Course".
3. All other items shall not be measured for direct payment and their cost shall be included in bituminous binder course and bituminous wearing course price.

12.5 PAVEMENT MARKINGS FOR TRAFFIC

12.5.1 Scope

1. These Works shall consist of the furnishing and application, of the traffic markings and to highway pavements for the guidance, control and safety of vehicular and pedestrian traffic.
2. White (Class A) and yellow (Class B) painted markings shall include centerlines, lane lines,

border (edge) lines, pedestrian crossing lines, stop lines, directional arrows, lettering and symbols using the following materials as appropriate and as on the Drawings.

12.5.2 PAINT AND THERMOPLASTIC MATERIALS

Reflective Paint (RP)

1. RP shall consist of a mixture of binder, white or yellow pigment and filler specifically compounded for cold application and adhesion to finished paved areas. Paint shall be reflective by adding reflective spheres before adhesion the film dries or sets.
2. White and yellow RP shall conform to AASHTO M248 Type III. The surface application glass spheres shall conform to AASHTO M247, Type I.

12.5.3 APPLICATION

12.5.3.1 Equipment for Pavement Marking

1. The equipment used for pavement marking shall consist of approved types of truck-mounted units, or motorized equipment, or manually operated equipment, depending on the type of marking required. The truck-mounted or motorized unit for centerlines, lines, and edge lines shall consist of a mobile, self-contained unit carrying its own material and capable of operating at a maximum speed of 10 km/h while applying paint. The hand applicator equipment shall be sufficiently maneuverable to install centerlines, lane lines; edge lines gore striping, run lines, crosswalks, stop lines, arrows, and legends
2. Spraying equipment shall be capable of satisfactorily applying the paint under pressure with a uniformity of feed through nozzles spraying directly on the pavement. Each paint tank shall be equipped with cut-off valves which will enable broken (skip) lines to be sprayed automatically. Each nozzle shall have a mechanical bed dispenser that will operate simultaneously with the spray muzzle and distribute the beads in a uniform pattern at the rate specified. Each nozzle shall also be equipped with suitable line guides and shall provide a method for cleaning the surface of dust just prior to paint application.
3. The spray machine for application of reflective paint lines and other markings shall have an attachment to accurately regulate the rate of application and a tachometer or other approved device to ensure uniform paint application at the designated rate. It shall be adjustable to enable the painting of 1 or 2 adjacent lines simultaneously along the centerline. The paint shall be properly agitated while in operation.
4. An automatic glass sphere dispenser with synchronized automatic cut-off shall be attached to the applicator machine. The dispenser shall utilize pressure type spray guns which will embed the spheres into the surface to at least 0.5 times the sphere diameter. The dispenser shall also be equipped with an automatic cut-off synchronized with the cut-off of the thermoplastic material.
5. Hand equipment shall be used only for painted markings, including arrows, crosswalks, stop lines, symbols and legends, and it shall hold a minimum of 25kg and not more than 100kg of molten material unless otherwise agreed between the Engineer and the supplier.

12.5.3.2 Setting Out and Pavement Preparation

1. The Contractor shall set out all control points necessary for locating paint lines and markings. On irregular widths of roads, the locations of boarder (edge) lines shall be adjusted so as to fall

continuously on the pavement.

The locations of all painted markings shall be accurately established and shall be subject to approval before application commences. Markers shall not be located over longitudinal or transverse pavement joints.

2. The area of road surface on which marking is to take place shall be free of dirt, grease, oil, moisture, loose or unsound layers, and any other material which could adversely affect the bond. The areas shall be thoroughly cleaned to the satisfaction of the Engineer before proceeding with painting.
3. Pavement marking shall not proceed when there is moisture on the pavement surface or the air is misty; or the surface temperature of the pavement is below 10 degrees C; or when wind or other conditions may cause a film of dust to be deposited on the surface, or in other conditions that, in the opinion of the Engineer, could displace, damage, or adversely affect the bonding of the material to the pavement surface. Any markings damaged due to water or rain within 20 minutes after application, shall be removed and replaced at the Contractor's expense.

12.5.3.3 Painting and Adhesive Film Application

1. The use of Class A (white) paint or Class B (yellow) paint and the type of paint material shall be in accordance with the design standards and as shown on the drawings.
2. Application of the various categories of paint to the pavement surface shall be carried out in accordance with the equipment manufacturer's recommendations and as shown on the drawings and directed by the engineer.
3. Painting applications may include centerlines, border (edge) lines, 'no passing' lines, intersection markings chevron striping (in gross areas), pedestrian crossings, letters, arrow, symbols and other special purpose pavement markings.
4. Preformed reflective thermoplastic film shall be utilized only where specified for markings such as intersection markings, lettering, arrows, symbols and other special purpose markings. Application shall be in accordance with the manufacturer's recommendations and shall be carried out in the presence of the Engineer.

12.5.3.4 Reflective Paint (RP) Application

1. Traffic paint shall be thoroughly mixed in the shipping container before placing in the machine tank. The paint machine tanks, connections, and spray nozzles shall be thoroughly cleaned each day with thinner before starting any spraying.
2. The minimum wet film thickness for all painted areas shall be 0.4 mm.
The minimum rate of application for 100 mm width paint lines shall be as follows:
 - a- Continuous (solid) paint lines: 40 ltr/km for smooth surfaces and 50 ltr/km for rough surfaces.
 - b- Broken (skip) paint lines: 14 ltr/km for smooth surfaces and 17.5ltr/km for rough surfaces (assuming gap length is double the length of paint line).Rates shall be modified proportionately for other widths of traffic lines.
3. The measured application rate shall not vary from the approved rate by more than 5% in any 1/km. At any point where a check indicates a variation in exceeds of 5% painting shall be stopped and the equipment adjusted or replaced. Identifiable areas of deficiency shall be corrected as directed.

4. Immediately following the application of paint, a uniform application of glass beads shall be applied at the rate of 0.6-0.7 kg/ltr of paint.

12.5.3.5 Protection of Markings

1. Immediately following the application of paint lines and other markings on pavement open to traffic, traffic cones and other devices shall be placed alongside or over the paint at intervals not exceeding 10 m and shall remain on place until the paint has dried.
2. Traffic shall be prevented from crossing wet paint lines and the Contractor shall use sufficient numbers of flagmen, barricades, or other protection, particularly at crossings to prevent traffic from crossing wet paint. Section of paint which have been damaged by traffic before the paint has cured, shall be repaired and pavement outside the painted area cleaned at the contractor's expense.

12.5.4 Sampling and Testing

1. All material shall be shipped to the job site in undamaged, sealed, original packaging clearly identifying each material as to name, color, manufacturer, batch number, and date of manufacture. All material shall be accompanied by certified test results verifying compliance with all specified physical and chemical requirements.
2. All paint products and other materials designated by the engineer shall be sampled for testing. Sampling shall be performed by the contractor in the presence of the engineer. Materials shall be sampled in their original containers. All samples shall be packaged for shipment as approved by the engineer. Samples shall be transported to the mobile field laboratory or to an approved independent laboratory, as directed by the engineer. Paint materials shall not be used until approved by the employer.

12.5.5 Measurement

Painted pavement lines and painted pavement markings shall be deemed to be included in the price of the painted surfaces.

12.6 CONCRETE CURBS

12.6.1 Scope

This work shall consist of furnishing and constructing concrete curbs and concrete paving to sidewalks as and where shown in the Drawings.

12.6.2 Materials and Precast Manufacture

12.6.2.1 Concrete

Portland cement concrete shall be class B 300 for all in situ and precast concrete unless otherwise indicated.

12.6.2.2 Mortar

Mortar shall consist of cement and fine aggregate having the same proportions used in the concrete construction.

12.6.2.3 Precast Concrete Units

1. All precast units shall be manufactured to the dimension shown on the drawings. Manufacturing tolerances shall be 3mm in any one dimension. End and edge faces shall be perpendicular to the base.
2. For horizontal curves of radius less than 10m, curb units shall be manufactured to the radius shown and in such circumstances where straight elements or portions of straight elements shall not be used.
4. Precast units shall be cast upside down in approved steel molds under conditions of controlled temperature and humidity. The engineer's approval of the samples will not be considered final and the engineer may reject any precast units delivered to the site which do not meet the required standards.

12.6.3 Precast Concrete Curbs

1. The sub-grade shall be excavated to the dimensions as shown in the drawings, and the surface of sub-grade shall be leveled and compacted to at least 95% AASHTO T180 maximum density.
2. The Base Coarse under the curb is to be placed to the required level and compacted and tested according to the base course specifications.
3. Forms for the concrete base shall be approved wood or steel. All forms shall be sufficiently strong and rigid and securely staked and braced to obtain a finished product correct to the dimensions, lines and grade required. Forms shall be cleaned and oiled before each use.
4. Concrete shall be placed, compacted and shaped to the sections shown on the drawings taking in account expansion joints. Concrete shall be compacted with an approved internal type vibrator or if approved, by hand spudding and tamping.
Edges shall be rounded if necessary by the use of wood molding or by the use of an edger as applicable. The concrete base shall be finished to a true and even surface with a wood float. Concrete shall be membrane or water cured for at least 7 days before precast units are placed thereon.
5. Precast units from approved factory shall be set accurately in position in mortar on the concrete base. Joints pattern precast units shall not be mortared unless otherwise shown on the drawings. Units shall be closely spaced and every 10 m run shall be provided with an expansion joint.
6. Where curbs or gutters are installed on existing concrete pavement and using epoxy resin adhesive, the installation procedures shall conform to those specified for raised pavement markers in Section "Pavement Markings for Traffic".
7. After curbs have been installed, forms shall be erected and concrete backing, shall be placed as shown on the drawings.
Pavement courses shall not be laid against curbs until the concrete backing has membrane or water cured for at least 14 days.
8. The tolerances on alignment of completed precast shall be as specified for in situ concrete construction.
3. The area adjacent to completed and accepted curbs shall be backfilled with approved material to the top edges of the curbs to 95 % AASHTO T180 maximum density.

10. The curb to be painted by white, red, and black colours according to traffic requirement, the paint must be after cleaning the curb, with one prime coat and two faces coloured approved road paints.

11. Test: 5 curbs must be tested for every 1000 curbs

12.7 INTERLOCKING TILES

The work includes supply, install and maintain of all forms, dimensions and colors of interlock tiles in accordance with the specifications and technical requirements of the contract and in accordance with the instructions of the Engineer. The Contractor shall comply with the following:

- Not to use broken or distorted tiles in any way, and the layers of tiles consist of:
Upper layer: cement, basalt and coloring pigment mix (not less than 10 mm).
Bottom layer: cement and aggregate mix.
- Not to fill the gaps between and around the tiles with concrete or cement mortar but in case of no way to install complete tile, mechanical or electrical cutter should be used. At the boundary of tiled area, ready made end pieces must be installed.
- Interlock tiles should be transported in palettes and using a crane mechanism or fork lift to upload and download tile packages.
- Installation of interlocking tiles might be carried out manually or automatically.
- Soiled or non-homogenous tiles must be replaced by clean and unharmed ones.
- Manufacturer, type, dimensions, color must be approved prior to supply of the tiles to the site.
- Average compression strength of the interlocking tiles must not less than 49N/mm² but not less than 40N/mm² for any specimen of the sample. Sample of interlocking tiles must be tested by an approved lab according to the international standards. Each sample contains at least 2 specimens per 1000 tiles.
- Average abrasion resistance of interlocking tiles should not be less than 3mm but not less than 4mm for any specimen at 440 revolutions of carborundum stone.
- Water absorption of the interlocking tiles should not be not more than 2% after 10 minutes and not more than 5% after 24 hours.
- Tolerance in dimensions should not exceed 2 mm in all directions.

The price of the interlocking tiles work should include the following according to the technical specification and instructed by the Engineer :

I. Supply and spread of dry, clean and coarse sand layer with thickness 5 cm below the tiles. Sand must be graded by mechanical or manual long straight stick taking into consideration the required slopes.

II. Supply and install of tiles according to the required size and color. Finish level of tiles must be even and straightness must be maintained along the area boundary. Tiles should be compacted mechanically using a plate compactor with area 0.35 - 0.50 m² , power 16-24

kN and frequency 75-100 Hz taking necessary precautions to avoid any damage to the tiles during the process of compaction. In case of unconstrained edges, compaction should be carried out at a distance not less than one 1 m from edge.

III. The gaps between the interlocking tiles should not exceed 3 mm.

IV. When testing the surface using a straight stick length of 3 m should not excess ± 5 mm.

V. Evenness of two adjoining tiles should not exceed 2 mm.

VI. The implementation of the edge beams is set first and then closing the spaces with interlocking tiles.

VII. Finish level should not exceed the design level by ± 5 mm.

VIII. Prior to tiling work, the concrete backing level of curbstone should be adjusted so that not to obstruct with the tiles level.

- Concrete edge beam B250 (Size 20×40 cm) should be constructed at the beginnings and ends of the interlocking tiles (unless otherwise noted in drawings and bill of quantities), including the necessary excavation and cutting the existing asphalt using a special cutter, as well as the shuttering and reinforcement works.
- The Contractor shall submit a statement of work as well as performing mockup of implementation before the start of work. The contractor must obtain the Engineer's approval of this plan before starting work .
- The Contractor shall take into account using the readymade starters $\frac{1}{2}$ or $\frac{3}{4}$ of the tile, depending on the proposed pattern.

Measurement will be engineering quantities so that calculating the net area of tiles laid on the ground. Area of manholes, storm water gullies, etc are to be deducted from the gross area.

13 –STORMWATER DRAINAGE SYSTEM

The stormwater drainage system consists of soakaway boreholes that penetrate the clay layers and extend in the sandy layer by five times the borehole's diameter.

Each borehole's center shall be identified in the field as presented in the detailed drawings.

Rotary drilling rigs mounted on truck with bucket auger shall be used to drill the boreholes according the designed depth and diameter. The drilling machine shall be able to drill all types of soil such as clay, rock lenses, back filling.....etc.

The boreholes internal edges shall be protected with non-woven geotextile to protect it from erosion.

The boreholes will be filled with gravel to allow rainwater to flow to the aquifer.

The following is the specifications of materials used:

17.1 Geotextile Materials

The Contractor shall furnish and place geotextile in accordance will these Specification and as shown on the Drawings or directed by the Engineer or his Representative.

All geotextiles shall be manufactured by and obtained from acceptable manufacturer. The manufacturer(s) shall have ample experience in the geotextile works.

The manufacturers need to be certified with ISO 9001 norm or equivalent approved certificate.

Before ordering, the Contractor shall provide the Engineer or his Representative with certified copies of the manufacturer's test results, which shall meet the specifications listed below.

Each 25 m² of geotextile shall be duly marked by the manufacturer showing the manufacturer's name, type of geotextile and manufacturing date.

No geotextile shall be used in the Works which were manufactured more than one year prior to arrival on Site.

Non-Woven Geotextile is used in the filter zone. It shall be laying inside the boreholes and over the filler zone according to the drawings. The geotextile is a polypropylene, staple fiber, needle punched non-woven type. The fibers are needled to form a stable network that retains dimensional stability relative to each other. The geotextile is resistant to ultraviolet degradation and to biological and chemical environments normally found in soils. The Non-Woven geotextile has the following minimum specifications:

- 350 g/m² according to EN ISO 29073/1
- 2.6 mm thick matching the requirements of EN 29073/2
- 22 kN/m maximum tensile strength according to EN ISO 10319
- 66% elongation at break according to EN ISO 10319
- 73 m².s water flow as specified in EN ISO 11058
- Resistance to Ultraviolet Rays
- Resistance to Rot and Vermin
- Resistance to chemicals

Joints

Lapped joints shall have a minimum overlap of 300 mm.

Transportation, Storage and Handling.

All geotextiles shall be transported, handled and stored fully in accordance with the manufacturer's recommendations throughout the period of shipment, land transportation, handling and storage. The geotextile shall be protected from direct sunlight, ultraviolet rays and

temperatures of more than 60°C. The geotextile rolls shall arrive on Site in their original wrapping which shall be maintained until immediately prior to usage. Unused portions shall be rewrapped.

The Engineer or his Representative may reject geotextile removed from protective cover for more than 72 hours, or if the geotextile has defects, tears, punctures, shows deterioration or damage incurred during manufacturing, transportation, storage or handling.

Formation

Geotextile formation for the purpose of this Specification means the surface on which or against which the geotextile is to be placed.

1. Before placing geotextile on excavated areas or fill the relevant earth work shall conform to the Specifications and must have been approved by the Engineer or his Representative.
2. The surface on which geotextiles are placed shall be relatively smooth, free of obstructions, depressions and soft pockets. Depressions shall be filled with compacted materials.
3. Before placing fill against gabions, the surface shall be free from protruding sharp wire ends and other objectionable matters which may damage the geotextile.
4. Before placing of geotextile, the formation shall be jointly inspected. Geotextiles shall not be placed unless approval has been obtained from the Engineer or his Representative.

Laying

The geotextile shall be placed manually and loosely without wrinkles. No geotextile shall be placed in the works which cannot be covered the same day with protective materials.

The Contractor, before starting the geotextile laying operations, shall submit to the Engineer or his Representative a method statement which shall include but not by way of limitation:

1. Proposed method of transport and handling from store to the relevant work site (location where the geotextile will be placed).
2. Arrangement of joints (the Contractor shall submit Working Drawings showing details).
3. Method of placing and securing true position during construction of overlying stone/ fill materials inclusive of manpower and equipment input.
4. Detailed planning.

17.2 Stone For Filter Construction

General

The Contractor shall provide filter stone in accordance with the Specifications and in conformity to the lines, levels and typical sections shown on the Drawings.

Stones for filter shall consist of clean, sound, particles of crushed hard and durable rock. The stone shall be such character that it will not disintegrate or erode from actions of air, wetting and drying. It shall be capable of being handled and placed without undue fracture or damage. The stone shall be free from coatings of clay, silt, vegetable matter and other objectionable matter.

Stone Furnishing and Stockpiling

The Contractor shall obtain and import if necessary stones material from a source approved by the Engineer or his Representative.

Before initial furnishing stone material, the Contractor shall present to the Engineer or his Representative for his information test results on representative samples which show that the stone meets the Specifications.

As to the grading requirements of the stone, the Contractor shall demonstrate at the source that grading tests meet the Specifications.

In any case, the Contractor remains responsible for the quality of the stone and the Engineer or his Representative may reject stone which does not comply with the Specifications at any time and place irrelevant whether or not the Engineer or his Representative witnessed tests at the source or approved to go ahead.

Stone quality shall be monitored through out the period of construction works and the Contractor shall ensure that the stone materials are conforming to size, quality, weight and shape specified herein.

The Contractor shall make temporary buffer stockpiles of stone in such quantities that at any time ample stone is available to meet the gabions construction as scheduled.

Stone sources shall be selected well in advance of the time the materials are required in the work.

Stone Quality and Testing

Rock for the stone filter shall comply with the requirements tabled in Table 17.1:

Table 17.1 Test requirements for stones

Property	Acceptance value	Test Standard
Average Bulk Density	2.3 kg at least	BS 812: Part 2:1995
Aggregate Impact value	30% maximum	BS 812: part 2:1995
Aggregate Soundness	Loss in mass after 5 cycles shall not be more than 18% for magnesium sulphate	Appendix B, BS 6349: Part 1: 1984 or ASTM C 88
Water absorption	2% maximum	BS 812: Part 109:1990

Stone Shape and Visual Inspection

The stone shall not contain more than 10 % by weight of flat or elongated fragments.

1. A flat particle is one having a ratio of width to thickness greater than five.
2. An elongated particle is one having a ratio of length to width of greater than three.

Apart from the specified rock properties, the grading and shape requirements, all rock shall be sound, compact, hard, dense, rough, durable rock, of good quality.

The rock shall be free from weathering, fissures, planes of weakness, blasting cracks and any other undesirable qualities which might be unacceptable in the opinion of the Engineer or his Representative.

Number of Tests

- a. Rock property test (Table 2.1) shall be carried out by the Contractor initially to substantiate the proposed source, and subsequently for each new source or in case the Engineer or his Representative has any doubt as to the rock properties.
- b. Grading tests shall be carried out by the Contractor as directed by the Engineer or his Representative and witnessed by him, initially to substantiate the proposed source and subsequently on a frequent basis to control the quality of the supplies (site stockpile) and the workmanship. As soon as the supplies and workmanship of the stone/rock is under control, grading tests shall be carried out each 500 cubic meters (bulk) unless otherwise directed by Engineer or his Representative.

The attention is directed that ultimately acceptance or rejection of rock/stone shall be at the

(temporary site stockpile in Gaza, or prior to placing rock/stone in the Works) irrelevant whether or not the Engineer or his Representative approved the source.

Stone Filter Construction

Before placing the stone filter in any section of the work, the relevant surface in that section must have been approved by the Engineer or his Representative.

The Contractor shall place the stone filter in bulk by machine in such a way that the stone filter is not unduly disturbed and damage is avoided.

The stone shall be placed in such a manner that specified grading is reasonably maintained. Direct dumping of stone from the quarry is prohibited unless otherwise approved by the Engineer or his Representative in order to avoid segregation of the stone. The aim of machine placing is to release the stones close to final position in the works. Any spreading by bulldozer or other equipment shall be done with due care to prevent breakage and segregation.

The Contractor shall demonstrate the suitability of his proposed method in the field and shall adapt as necessary.

The Contractor shall submit to the Engineer or his Representative before starting the stone fill operations a method statement which shall include but not by way of limitation:

1. Loading at the stockpile area.
2. Transport from stockpile to the work site with due regard to traffic requirements, access/construction roads, tides etc.
3. Method of finishing surface which is to receive the filter stone.
4. Method of placing and spreading.
5. Details of manpower and equipment.
6. Production output backed up cycle times.
7. Detailed planning.
8. Quality control and testing.

17.3 Geo-Membrane

High-density polyethylene (HDPE) Geo-membrane of minimum 3 mm thick shall be used in the locations as indicated in the drawings below the water tank.

The sheet must be manufactured with the highest quality resin specifically formulated for Geo-membrane.

The Geo-membrane should satisfy the following minimum specifications:

- 3 mm thick matching the requirements of ASTM D-5199
- 0.95 g/cm³ density according to ASTM D-1505
- 32 N/mm Strength at Yield (both directions) according to ASTM D-638/6693 Type IV
- 15% elongation at Yield (both directions) according to ASTM D-638/6693 Type IV
- 55 N/mm Strength at Break (both directions) according to ASTM D-638/6693 Type IV
- 750% elongation at Break (both directions) according to ASTM D-638/6693 Type IV
- 265 N Tear Resistance according to ASTM D-1004
- 650 N Tear Puncture Resistance according to ASTM D-4833
- 2.0-3.0 % Carbon Black Content according to ASTM D-4218
- Carbon Black Desperation 1 Category according to ASTM D-5596
- Stress Crack Resistance ≥ 500 hr according to ASTM D-5397

EXECUTION

Site Preparation

All required grading, grooming and construction quality assurance (CQA) testing on any soil to be covered by the geo-membrane shall be completed and accepted by the Engineer prior to geo-membrane placement.

The surface to be covered by the geo-membrane shall be cleared of sharp objects, angular stones, sticks, or any materials that may contribute to punctures, shearing, rupturing or tearing of the geosynthetic materials. The geo-membrane subgrade shall have a smooth, finished surface, free from pockets, holes, ruts, and discontinuities that, in the judgment of the Engineer, will cause bridging of the material. The subgrade shall be inspected for unsuitable areas or soft spots before the geo-membrane is placed, and additional surface preparation will be required to eliminate any unsuitable areas as determined by the Engineer.

The Contractor and Engineer shall carefully and completely inspect the subgrade surface immediately prior to the deployment of each geo-membrane panel. No geo-membrane shall be placed on unsuitable subgrade surface, or without the Engineer's written approval. The Engineer and the Contractor shall furnish their signatures on a Subgrade Acceptance Log prior to the installation of each panel or series of panels placed on a daily basis.

Under no condition shall the geo-membrane be placed over standing water on the subgrade.

Seaming Methods

A six - inch wide overlap must be cleaned of all dust, dirt or foreign debris no more than 30 minutes prior to welding. Only clean, soft rags will be used for cleaning. If mud has adhered to the sheet surface overlap area, it will be removed with clean water and allowed to dry prior to seaming.

During the cleaning operation, the sheet will be inspected for defective areas which must be removed and/or repaired prior to seaming. The seaming operation requires a solid, smooth subsurface. Subsurface voids, hard nodules, rocks, soft areas or unsuitable conditions will be removed or repaired prior to seaming during subgrade preparation.

Seaming cannot be conducted in the presence of standing water. Wet surfaces must be allowed to dry. A slip sheet or seaming board may be used to lift the geo-membrane above damp surfaces. If wind conditions contaminate the seaming area or displace the geo-membrane sheets, temporary ballast and additional cleaning procedures will be required.

The geo-membrane panels shall be joined utilizing approved seaming methods. Dual-track fusion welding shall be the required method on all seams where it is feasible. Chemical welds shall be made only where approved by the Engineer.

All geo-membrane surfaces that are to become a seam interface are to be free of dust, dirt, excess moisture or any other condition that may affect the quality of the seam.

Seaming will not be allowed during rain or snowfall, unless proper precautions are made to allow the seam to be made on dry subgrade and geo-membrane materials. If weather conditions are not satisfactory, panels will not be put into place. If panels are placed and pulled out, the installation crew will do what is necessary to finish or secure those individual panels that day.

The field seams shall be produced using one of the following methods:

- **Dual-Track Thermal Fusion Weld** – All field seams shall be fused using Dual-Track Thermal Fusion Welding. A seam produced by melting the two intimate surfaces by running a hot metal wedge or hot air device between the surfaces, followed immediately by pressure to form a homogeneous bond. This seam has a centre air channel for non-destructive testing of the seam. Panels to be seamed shall be overlapped sufficiently to allow proper destructive testing of seams. The Contractor

shall mark the liner where the Dual-Track Fusion Welding machine settings are adjusted (including speed, temperature and pressure). Measurable setting values shall be indicated on the liner.

- Chemical Fusion Weld – Chemical Fusion Welding shall only be used for repairs and detail work. All field seams will be a minimum of 2 inches wide. A sufficient amount of chemical fusion agent will be applied that, upon compressing the seam surfaces together, a thin excess of chemical fusion agent will be forced out. A high durometer rubber, nylon or steel roller will be used to compress the seam surfaces together until a bond is formed. Roller action will be at a parallel direction to the seam's edge so that excessive amounts of chemical fusion agent will be purged from between the sheets. Trapped chemicals should be rolled out of the seaming area. Care will be exerted in applying the chemical fusion agent. A continuous wet layer of chemical fusion agent is necessary to prevent a leak at the tie - in point between the last chemical fusion agent application and the next. If the chemical fusion agent, that is initially shiny when applied, takes on a dull filmy appearance, the interfaces may require a faster closing together or the ambient temperature is too high to continue seaming. The installer will monitor this condition at sheet temperatures over 105°F. At the completion of seaming, all rags, chemical containers, etc., will be properly removed from the geo-membrane.

INSTALLATION

The number of panels to be deployed in any day will be limited to the number of panels which can be seamed that day. The geo-membrane will be placed over the prepared surface in such a manner as to assure minimum handling.

Based on the approved geo-membrane panel diagram and material certifications, the individual panels will be numbered and seams will be identified by using the panel numbers that create the seam. The panels shall be installed in a manner that minimizes seams. Where ever possible longitudinal seams shall be oriented to be no greater than ten degrees from parallel with the direction of the slope. Cross seams (i.e. those seams which join the ends of contiguous panels) shall not be placed on any slope that exceeds a ten percent grade. All panels placed on slopes shall be cut no closer than five feet from the top of the slope or ten feet from the toe of slope. All seam overlaps shall be shingled in a downslope direction. In no case shall parallel seams be placed within five feet of the centreline of any leachate collection pipe.

During installation, and any other period of exposure of geo-membrane, pedestrian and equipment activity over the geo-membrane shall be kept to a minimum, and restricted to only that which is necessary for geo-membrane construction.

Smoking is not permitted on the geo-membrane.

Construction workers shall take precautions not to damage the geo-membrane surface. Construction workers shall wear smooth-soled footwear, and exercise care not to drag tools across the geo-membrane surface. All large tools are to have smooth base plates or shoes. Construction and landfill staff shall be informed of the restricted access to areas of geo-membrane placement by use of barriers and signs posted as necessary.

The Contractor shall perform all activities of geo-membrane construction in such a way as to avoid damage to the geo-membrane. Any damage caused to the geo-membrane by the Contractor shall be repaired or the material replaced at the expense of the Contractor.

No tracked or wheeled vehicles, other than low ground pressure ATVs as preapproved by the Engineer, shall be permitted on the geo-membrane prior to placement of adequate soil cover, as determined by the Engineer.

The Contractor shall complete his work in a manner that will prevent water or wind from getting under the partially installed geo-membrane. This could include, but is not limited to,

installing sandbags along the leading edges. Should excessive moisture become trapped below the geo-membrane, or should wind damage occur due to the negligence of the Contractor, at no extra cost to the OWNER, will be required to perform all work, including removing and replacing as much of the in-place geosynthetic material as the Engineer directs, to assure that the integrity of the geo-membrane and the underlying sub-base or geosynthetic clay liner (GCL) has not been compromised.

Seams shall be welded throughout the entire length of the panels during initial panel seaming.

Sandbags or other approved ballast shall be used to prevent bridging or material movement in areas such as toe of slope or near sumps. Ballast shall not be used to force the geo-membrane into contact with the subgrade.

Special care shall be taken to prevent tensile stress in the geo-membrane and geo-membrane seams in all corners and grade changes.

The Contractor shall exercise his best judgment and care to provide sufficient slack in the PVC geo-membrane.

The geo-membrane shall not be installed when ambient or sheet temperatures are below 32° F, when the sheet temperature exceeds 158° F, or when the air temperature is above 120° F unless the Contractor demonstrates, to the satisfaction of the Engineer, that procedures can be implemented which will result in the proper installation and seaming of the geo-membrane.

Adjacent geo-membrane panels shall be allowed to reach essentially equivalent temperatures prior to seaming to avoid development of fish mouths.

If fish mouths are created at the seam over laps, they shall be cut to achieve a flat overlap.

Geo-membrane covering operations shall be performed in a manner that does not damage the geo-membrane lining system. Geo-membrane covering operations shall be performed only in the presence of a Construction Observer such that the condition and cleanliness of the geo-membrane is observed at the time the material is covered, and any effects of the covering operation on the geo-membrane lining system can be observed.

REPAIRS

All geo-membrane panels and seams shall be examined by the Engineer for defects, holes, blisters, undispersed raw materials, and any sign of contamination by foreign matter. The geo-membrane surface shall be clean at the time of examination. Each suspect location shall be repaired and all repairs shall be non-destructively tested.

Damaged geo-membrane shall be removed and replaced with acceptable geo-membrane if damage cannot be repaired to the satisfaction of the Engineer.

Any portion of the geo-membrane, or any portion of a seam exhibiting a flaw or failing a destructive or non-destructive test, shall be repaired as follows:

- Geo-membrane patches shall be used for holes over 1/8 of an inch in diameter, tears, and contamination by foreign matter. Patches shall be constructed of the same geo-membrane, and will be joined to the panel using adhesive or chemical fusion welding where possible.
- Geo-membrane patches or caps shall extend at least 6 inches beyond the edge of the defect or failed seam area, and all corners of material to be patched. The corners of the patch shall be rounded.
- Geo-membrane caps shall be used to repair failed seams that are left in place. Seams that fail destructive or non-destructive testing may also be removed and replaced if determined necessary by the Engineer.

14 -STRUCTURAL STEELWORK

Structural steel work shall be provided and fixed complete with all plates, cleats, bolts etc. , cut to lengths and sizes and drilled all as shown on the Drawings .

Hot rolled and hollow steel sections shall be mild steel Grade 43A to the requirements of BS 4360.

Steel tubes shall be seamless tubes in accordance with BS 1387 or with BS 1775.

Unless otherwise required by the Contract all forms of steel used shall be of standard section and shall be of the exact dimensions. Should the Contractor be unable to obtain steel to the required dimensions he shall submit alternative proposals to the Engineer for his approval. Two copies of all detailed working drawings , calculations etc. , prepared by or on behalf of the Contractor shall be submitted to the Engineer for his approval .

Any approval by the Engineer shall in no way relieve the Contractor of his responsibilities for the work under the Contract.

Black and galvanized bolts shall be to BS 1760 UNC threads or BS 916 Whitworth threads. High strength friction grip bolts shall be to BS 3139 general grade and shall be of the load indicating type. Bolts shall be of sufficient length to show at least one full thread beyond the nut after tightening.

Washers, where used , shall be to BS 3410 with a tolerance of 1.5mm on the diameter of the hole . When bolting to diminishing sections tapered washers shall be used.

Welding electrodes shall comply with the requirements of BS 639.

The workmanship shall be of the best quality and all persons employed in the factory or site shall be competent and skilled in their respective trades.

The design and detailing of connections and workmanship shall be in accordance with the Drawings and BS 5950 to transmit the loads specified by the Engineer.

The work shall be erected, fitted and temporarily bolted together for the approval of the Engineer before any riveting or welding is carried out.

During erection and prior to the construction of any necessary stiffening members, temporary bracing shall be provided as necessary to ensure the stability of the framing against wind or accidental forces.

Shop and site joints shall be formed either by riveting, welding or bolting to suit the plant, equipment and erection procedure of the steelwork Contractor, due regard being paid to efficiency, appearance and ease of maintenance.

Site connections generally shall be made with galvanized bolts , with a minimum of two bolts to any connection, except where fitted bolts, high strength friction grip bolts, or site welding, are specifically referred to in the Specification or on the Drawings.

High strength friction grip bolts shall be tightened by a part-torque part-turn method. After bedding down of the joints, each nut and the protruding threads of the bolts shall be permanently marked to record their relative positions. The nuts shall then be tightened to the approval of the Engineer by the part-turn of the nut method. High strength friction grip bolts will generally be preferred to fitted bolts. The surface of members joined by friction grip bolts shall be free from oil and paint etc. . In portal frame site connection at apex and eaves where H.S.F.G bolts in tension are employed, such bolts shall be torqued up to their proof load.

Plates and sections shall be true to form. Stiffeners, plates and the like shall be ground to fit the profile of the member. Sections to be cut to exact lengths shall be accurately cold sawn or machined . Preparation of edges to be done by machine. Cold sawn, machine-cut edges shall be cleaned free of burrs and slug and left as smooth and regular as those produced by edge planning. All holes shall be machine drilled, not punched or flame drilled.

Not less than 28 days before the fabrication of steelwork is to begin the Contractor shall submit detailed shop drawings to the Engineer. Fabrication shall not commence until the Contractor has received the Engineer's written approval of his proposals. Such approval does not in any way relieve the Contractor of his responsibilities to produce an adequate and safe scheme.

Castellated beams shall be detailed such that any series of similar beams castellations shall line through, and be symmetrical about mid span, or crank if applicable.

Chequer plates may be clipped to supporting members unless stated otherwise in the Contract Drawings. The surface patterns of adjacent plates shall be matched to lay in the same direction.

Purlins shall be galvanized and fabricated to span continuous over two bays. To achieve this purlin joints shall be staggered, with suitable continuity joints for single bay length members "U" type purlins shall be connected only by bolts (no welding).

Holding down bolts shall be supplied as required for building into the supporting concrete members.

Riveting shall be carried out in accordance with BS 4620 and BS 275 using rivets with snap heads and points and of sufficient length. Surfaces in contact of members to be riveted shall have all burrs removed to ensure perfect contact. Riveting shall be carried out carefully so as to avoid distortion of the riveted members.

Welding where needed shall be carried out in accordance with BS 1856 or BS 938 using electrodes as specified in BS 639 or BS 1719. Welders shall be suitably qualified and experienced and efficient methods shall be employed to remove all welding slag, spatter and flux residues thoroughly.

When directed by the Engineer and before fabrication is commenced, welding and flame cutting procedure trials (for plates only) shall be carried out using representative samples of materials selected by the Engineer to be used in the work, which shall include:

(I) Welding procedure in accordance with BS 1856.

(II) The heat control techniques required to ensure that the flame cut surfaces of steel are free from any defects which would be detrimental to the finished work.

The trials shall include specimen weld details representative of the actual construction which shall be welded in a manner simulating the most unfavorable conditions liable to occur in the particular fabrication.

The preparation and painting of the steelwork shall be in accordance with the requirements of BS CP 2008. Non galvanized steelwork shall be shot or grit-blasted free from all mill scale, rust, dirt and other deleterious matter and immediately painted or sprayed with one coat approved zinc primer containing not less than 90% zinc.

All damaged coatings and areas around site connections including the bolts will be derusted as necessary and touched up on site and all steelwork shall be given a further three coats of a similar coating. Contact surfaces shall be brought together while still wet.

15 -LANDSCAPING

The work covered by this division consist of providing all plant, labour and materials and performing all operations in connection with ground covers, plants, trees and soil.

15.1 *Product Delivery*

The Contractor shall notify the Engineer of the delivery schedule 48 hours in advance so that plant material may be inspected on arrival at the site. Unacceptable plant material shall be removed from the site immediately.

The Contractor shall produce an itemized list, in duplicate of the actual quantity of plant material in each delivery so as to ensure satisfactory coordination of deliveries and to expedite the required inspection at the site. The itemized list of the plant material for each delivery shall include the pertinent data as specified in the list of required plants. The list and the necessary inspection certificates to accompany each delivery shall be given to the Engineer prior to acceptance and planting of the plant material.

Plant material delivered by truck shall be loaded so as to provide adequate protection against climatic, seasonal, and breakage damage during transit. Entire loads of plants shall be securely covered with tarpaulin or canvas to minimize wind whipping and drying. Rail cars or air freight containers shall be carefully loaded and adequately ventilated to prevent excessive transpiration of the plants during transit. Shipments made by rail or air to local freight yards or terminals shall be given special attention to ensure prompt delivery to the site and careful handling. Container grown trees shall be protected from sharp jolts during transit by tying the main stem to the container, using a strong twine from cutting on to the stem from becoming loose in the soil mould, cracking the soil mould, or breaking the delicate surface roots. Care shall be taken to prevent the twine from cutting into the stem by using a padding of burlap or other suitable material. The ball of the large balled and burlapped plants shall be set in wood crates or properly tied to a base to provide stability during transit. To prevent damages of the bark of trees with a stem diameter of more than 50 mm a special jute double layer should cover the stem, from the stem base up to the first branches. This should be done before any loading and transport operations. Additionally, the contractor has to ensure that the whole plant material is sprayed with insecticides and fungicides before transportation. This must be done twice with two weeks interval between the spraying operations.

Soil ingredients like fertilizer, peat moss, and manure shall be delivered to the site in the original unopened containers, bearing the manufacturer's name, trade name or trademark, the guaranteed chemical analysis and any other information needed to comply with local statutes. In lieu of containers soil additives may be produced in bulk with a certificate indicating the above information accompanying each delivery.

15.2 *Product Storage*

Plants not planted on the day of delivery at the site are to be stored and protected as follows:

Especially, if plants are imported, a heeling-in nursery should be provided, where plants have an opportunity to recover from their travel and get used to their new environment. Plants require a minimum of six weeks in this holding area. Time for this process must be incorporated into the construction schedule. This plant staging area should protect the plants from sun and wind and must have Irrigation. It should be located in a suitable area on site, which provides this protection. If no such area exists, the contractor shall be required to construct a lath house or other suitable construction which provides sun and wind protection for the plants.

All plants stored on site shall be protected from drying out at all times by covering the balls or roots with moist sawdust, wood chips, shredded bark, peat moss, or kept moist until planted by watering with a fine mist spray.

Seeds have to be stored dry and in air-conditioned room with a maximum temperature of 25 degree Celsius .

Soil additives and other materials shall be kept in dry storage away from contaminants.

15.3 Product Handling

Care shall be taken to avoid damaging plants being moved from the nursery or storage area to the planting position. Plants shall be protected from drying out at all times. Balled and burlapped plants shall be handled carefully to avoid cracking or breaking the earth ball. Plants shall not be handled by the truck of stems.

Under no circumstances shall plants be dropped from box cars or trucks to the ground. Cracked or mushrooted plants balls will be rejected. Bare-root plants shall be "paddled" when removed from the heeling-in nursery to protect the roots from drying out. Plants shall be protected from drying out by a covering of burlap, tarpaulin or mulching material during transportation from the heeling-in bed to the planting position. Damaged plants will be rejected and shall be removed from the site immediately.

Big trees with a stem diameter of more than 100 mm the following will be necessary:

Wooden battens (100 x 60 x 600 mm) shall be adequately padded with several layers of burlap and firmly wired in place around the trunk for protection from lifting devices during digging, transportation and planting operations. Under no circumstances will nailing of battens to trunk be allowed. Digging shall be by hand or by mechanical means or both.

15.4 Plants And Seed Products

Ground Covers

Ground covers shall be vigorous, have the number and length of runners and clump size specified, and the proper age for the grade of plants specified. Only ground cover plants well-established in removable containers, integral containers, or formed homogeneous soil sections shall be used. Plants shall have been grown or acclimatized under climatic conditions similar to those in the locality of the project. All ground cover plants shall be free from pest and disease, eggs and larvae and should have a vigorous root system.

The ground covers to be used for slopes are *Carbobrotus Edulis*.

The minimum sizes of all plants for acceptance are measured before pruning and with branches in normal position.

They shall have at least three well-developed branches or runners and grown for a period of at least 6 months. The minimum size of the root ball shall not be less than 1 liter in volume.

Climbers

Climbers shall be symmetrically developed, well-branched, their structure and habit of growth shall be typical of the species or variety. Shrubs shall have grown in a container at least for six months for the root system to have developed sufficiently to hold its soil together in a fine and integral manner. No plants which are loose in their container shall be accepted. Shrubs shall be free from disease, pests, eggs or larvae.

Climbers to be used in the work shall be Evergreen and Bougainvillea.

Climbers shall be measured when branches are in normal position from the ground level to the top of the shrub.

Trees

Trees shall be symmetrically developed, their structure and habit of growth shall be typical of the species or variety, and shall have straight boles or stems free from objectionable disfigurements. The side branches shall start at least 500 mm from the ground line. Trees with abrasion of the bark, sunscalds, disfiguring knots, or fresh cuts of limbs over 30 mm which have not completely calloused, shall be rejected.

If trees are container grown at least for 6 months, they shall have a sufficient root growth to hold the earth intact when the container is removed.

If trees are imported, the contractor shall conform to the local regulations dealing with the importation of plant material.

If not container grown, trees shall be balled with firm, natural balls of soil. Balled and burlapped plants shall be wrapped firmly with burlap, strong cloth or plastic and tied. The wrapping material shall be capable of rotting in the ground and shall not be permanent nature.

Calliper measurement shall be taken at a point on the trunk 250 mm above natural ground level for trees up to 100 mm in diameter, and at a point 300 mm above the natural ground level for trees 100 mm in diameter. Spread dimensions shall refer to the main body of the tree and not from branch tip to tip.

15.5 Soil

Soil shall be free of admixture, subsoil and foreign matter and shall be taken only from well-drained areas, free of objects larger than 20 mm, and shall have the following characteristics :

Clay max. 60 %

Sand min. 40 %

pH value max. 8.0

The Contractor shall provide soil analysis, which has to include the pH value. The electrical conductivity, CaCO₃, texture as well as the contents of nitrogen, phosphorus, potassium and magnesium. The maximum levels of acceptance are:

Available phosphorus P₂O₅ : 10 mg/100 g soil

Available magnesium Mg : 10 mg/100 g soil

Available potassium K₂O : 40 mg/100 g soil

The value of electrical conductivity shall not be higher than 2000 micro mhos/ cm- if it is higher, leaching of the soil in a well-drained area will be necessary with a suggested water quantity of 300 ltr/m² with a soil depth of 300 mm.

To get top soil, this wadi soil shall be mixed with sweet sand and soil improvers according to sand and soil analysis, and as stated in the project documents.

The following mix states an example.

Alluvial soil 50%

Sweet sand 20 %

Soil improvers:

Organic fertilizer 5%

Peat moss 10%

Inorganic fertilizer 200 gr/m³

Sand

Sand shall be natural, free of toxic material, friable and typical of the locality. Sand shall be reasonable free from subsoil, stones, earth dods, sticks, stumps, clay lumps, roots or other objectionable matter or debris and have the following characteristics:

Clay (less than 0.002 mm)	max. 3%
Silt (0.002 - 0.005 m)	max. 7 %
Sand (0.05 - 2 mm)	min. 90 %
pH value	max. 8
Electrically Conductivity	less than 1000 micro mhos/cm
Exchangeable sodium (ESP)	less than 10 % in ammonium acetate .

Top Soil Additives

Inorganic granular compound fertilizer, uniform in composition, dry and free-flowing shall be used. They shall be delivered in original unopened containers and bear the manufacturer's analysis.

They shall contain N (Nitrogen), P2 O5 (Phosphorus) and K2 O (Potassium) in an adequate mix to suit the purpose. The regulations governing inorganic fertilizer edited by the Ministry of Agriculture shall be adhered to.

Organic fertilizer, Manure shall be a commercial product thoroughly pulverized, sterilized, decomposed, equivalent in every respect to packed sheep manure. Green manure shall not to be used.

Peat moss shall be of a quality acceptable for use as a soil amendment and shall have a pH range from 3.7 to 5.0. It shall be unfertilized and consist of sphagnum only.

Shredded bark made from conifers shall be proprietary decomposed bark in sealed containers and shall have the following specification:

Maximum water capacity	50 %
Nitrogen stabilised	
pH value	5, 5-7

available nutrients:

Nitrogen N	100 - 250 mg/ltr
Phosphorus P2 O5	200- 400 mg/ltr
Potassium K2 O	200-600 mg/ltr
Magnesium Mg.	300 mg/ltr

Other soil additives such as phosphates can be used with the approval of the Engineer. The materials mentioned above are listed as examples only and are not limiting.

15.6 Irrigation Water

Water for irrigating plants and for leaching operations should be fresh water. The contractor has to supply water from the sources determined by the Engineer.

The contractor has to carry out irrigation for not less than three hours every day for the first three weeks after planting, before handing over the work.

15.7 Accessories

Staking

Stakes for supporting trees shall be of healthy wood, uniform in size, reasonably free from knots and capable of standing in the ground for at least two years. For small trees with a clear stem of up to 1 meter, a stake of minimum 50 mm in diameter and 2 meter in length (750 mm in the ground) shall be used. For larger trees with clear stem of up to 1.8 meter, a stake of minimum 75 mm in diameter and

3 meter in length (1.0 meter in the ground) shall be used.

For trees with clear stem of more than 1.8 meter or 3 meter in height, the method of wiring shall be used.

Tree Wrapping Material

Tree wrap shall be two thickness of kraft paper glued together with a layer of bituminous material. Wrapping material shall be a minimum of 100 mm in width and have a stretch factor of 33 1/3 percent. Twine for tying shall be a lightly tarred medium of coarse sisal yarn.

Wiring

Wire for tree bracing and guying shall be pliable 2 mm to 3 mm diameter galvanized soft steel wire. Cable shall be 4.5 mm diameter, seven-strand cadmium-plated cable. Cable clamps and tumbuckles shall be galvanized steel of size and gauge to provide tensile strength equal to that of the cable. Tumbuckle opening shall be at least 75 mm. Chafing guard shall be a two-ply reinforced rubber or plastic garden hose of uniform colour throughout the work.

Pit Filling

Porous fill for plant pit and bed drainage: Granular fill for filling over excavations and for bedding of pipes shall consist of uniformly graded sand stone, gravel, or stone screenings free from soft or harmful particles or other objectionable material.

15.8 Execution

Inspection

Plants shall be subject to inspection and approval at the place of growth and upon delivery for conformity to project documents as to quality, size and variety.

The source and quality of soil and sand shall be subject to inspection and rejection upon delivery at the site or during the progress of work. The contractor shall ensure that an independent soil analyst prepares a physical and chemical analysis of the soil in accordance with the top soil specification together with a report and recommendations on fertilizer treatment. The soil analysis report, fertilizer recommendations and soil source shall be made available to the Engineer prior to approval.

No soil shall be brought on site prior to approval by the Engineer. The approved fertilizers and other soil improvers shall be added to the top soil in accordance with the soil analyst's recommendations.

Water has to be tested periodically and also throughout the maintenance period. The contractor shall provide equipment for testing the electrical conductivity of water.

Preparation

The soil shall be conditioned by adding soil amendments and nutrients in compliance with this specifications and the recommendations of the soil analysis report.

Fertilizer shall be applied not more than 24 hours in advance of tilling operations. Fertilizer shall be applied not

more than 24 hours in advance of filling operations.

Fertilizer shall be applied not more than 24 hours in advance of tilling operations. Fertilizer shall be

spread with

a fertilizer distributor. All amendments and nutrients shall be thoroughly mixed and incorporated into the soil by using a roto-tiller.

The seed bed shall be raked, dragged and then rolled making passes in two directions. Tillage depth shall be, 300 mm. Before during and after all mixing operations, water shall be added to soil and soil additives.

Stockpiled, wind blown sand shall be cleaned of all stones, sticks, plants and other foreign materials before being spread.

Sand shall be placed and spread over all areas not required to be developed otherwise. Sweet sand shall be placed, and spread in all areas designated for planting and garden areas to a depth of 150 mm, including filling plant pits to the required depths. Both types of sand shall be supplied and installed to a depth sufficiency greater than required so that after natural settlement the completed work will conform to the lines, grades and levels indicated.

Vegetation surfaces shall be fine-graded after applying soil improvements materials. Surfaces are to be compacted in such a way as to prevent subsequent setting, and without damage to any roots to a standard proctor density of 80 to 85 %.

After sand has been spread, it shall be carefully prepared by harrowing and hand raking. All large stiff clods lumps, brush, roots, stumps, titter and other for lawn areas shall be left smooth for ease of mowing.

15.9 Planting

The season for planting materials other than bare root plants shall be between November and March. Bare root plants should be installed during the months of January and February.

Lawn

Green areas must have a layer of top soil mix with a minimum depth of 300 mm. Before seeding the ground level shall be prepared by leveling + 20 mm on 10 m distance and stones and branches shall be removed .

Especially edges and connections to constructions have to be compacted.

Ground Covers

Planting season for ground covers shall be between November and March.

Ground covers beds shall be dug to depth of 400 below final grade and filled up with top soil. Rocks and other underground obstructions shall be removed to a depth necessary to permit proper planting.

After watering the soil, the ground covers shall be located on the bed in final position. After excavation, ballad and burlapped plants, shall be set in sweet sand which, shall be compacted around bases of balls to fill all voids. All burlap, ropes and containers shall be removed from the root balls. Roots of bare root plants shall be property spread out and sweet sand carefully worked, or frayed roots shall be cut off clean.

Shrubs And Trees

Planting season for Shrubs and trees shall be between November and March.

The location of all plants shall be staked out before excavating plants pits. If pits are prepared and backfilled prior to planting, their location shall be marked and recorded on drawings so that when planting proceeds they can easily be located.

Plants Pits Plant pits shall be excavated with sides as nearly vertical as possible with following sizes:

Shrubs : Shrub pits shall be 300 mm greater in diameter than the spread of the roots and sufficiently deep to allow a minimum of 100 mm top soil mix under the root balls. If the height of shrubs is not more than 80 cm, the size of the shrub pits should be 500 x 500 mm .

Trees : Tree pits shall be 600 mm greater in diameter than the ball of earth or spread of roots of the tree and sufficiently deep below root system to allow for a 150 mm thick layer of planting soil beneath the ball or roots. If the tree is not higher than 2 meters, the tree pit shall have a minimum size of 1000 x 1000 x 1000 mm.

In salty ground, all shrubs and tree pits shall be irrigated with sweet water for two consecutive days to ensure adequate leaching of the salt. The water applied per day shall be twice the volume of the pit. The bottom of the pit shall be filled with sweet sand about 500 mm deep. If there is a rocky ground underneath stone mulch shall be filled in about 200 mm deep. Between the stone mulch and the top soil, a filter sheet of fiberglass shall be installed. The rest of the plant pit has to be filled with top soil .

Before planting container grown plants some of the roots shall be cut and removed, so that they are matted at the bottom circling around the outside of the root ball. In freeing the roots at the periphery of the soil, some of the soil shall be broken away to provide better contact between the root ball and the fill soil. With balled and burped plants the burlap shall be folded back at least 5 cm below the soil level. The burlap shall be sliced carefully on the sides and at the bottom of the root ball to allow for easy root penetration. The hole shall be backfilled with top soil. Then a shallow basin shall be built around the tree pit, so that water soaks down into the root ball.

Staking should be done to support and protect the plant. It shall be done at the same time as planting. For vines only one stake shall be used, whereas for trees two stakes are necessary. The trunk shall be tied to the stakes in one level.

Stakes shall be at a right-angle to the most troublesome wind. Trees with a height of more than 3 meters or with a clear stem of more than 1.8 meter have to be anchored using 3 stakes and guy wires.

15.10 Landscape Maintenance

Maintenance

Maintenance shall commence immediately after each plant is planted and shall continue in accordance with the following requirements:

All planting shall be inspected at least once monthly during the maintenance period.

All site planting shall be maintained in a healthy growing condition until completion of the maintenance period.

Maintenance shall include watering, weeding, cultivating, mulching, fertilizing, tightening and

repairing of guys, removal of dead materials, resetting plants to proper grades or upright positions, spraying against insectal disease and all other necessary operations normally required to sustain, healthy growth. All wrapping and guying material shall be removed at the end of the maintenance period.

Replacement

Replacement shall be made by the contractor of any trees or plants that are dead or that are in unhealthy or unsightly condition or that have lost natural shape due to dead branches, excessive pruning or inadequate or improper maintenance.

All replacement planting is to be done no later than the earliest planting season following receipt or request for replacement from Engineer.

Ail areas damaged by tree or shrub planting or replacement operations are to be fully restored to their original condition.

16 -PLUMPING AND SANITARY INSTALLATIONS

16.1 Scope of work

The Contractor shall furnish all labors, materials, equipment tools, appurtenances, services and temporary work to provide and complete the several plumbing and drainage systems all in perfect working order. This work shall include but not be limited to the following:

- Excavating, backfilling, breaking in wall, concrete encasement and reinstatement works.
- Water supply systems including cold and hot water services.
- Waste disposal system.
- External gravity sewer network.
- Gas system.
- Water tanks and water pump.
- Plumping fixtures.
- Firefighting system.
- Rainwater services.
- Testing of all piping systems and equipment and other devices to demonstrate that the entire installations are in perfect working order.

All fixtures and materials shall be brand new bearing stamped ratings as required and must be approved by the Engineer prior to their use.

The foregoing sub-paragraphs are not intended to itemize all works required by this section of the Specifications and are only for the purpose of outlining the extent of work for the guidance of Tendering.

16.2 General Description of the work

The sanitary works in the building shall consist of all water supply to and water discharge from all the sanitary fixtures.

Water distribution to all floors is effected from a roof tank fed from the main city network.

Hot water is generated by means of water heater or solar system and stored in hot water storage tank.

Drainage of the ground floor is discharged by gravity from individual points to a system of manholes which will be later discharged to any close outlet.

All riser branches must be provided by elbows, Tees or nipples with gate at the point of connecting with branches.

Clean out opening must be provided where shown on drawings and where required.

Slope of drain pipes to be 1cm/mr unless otherwise indicated.

Vent for sewage pipes to be 1 meter above finished roof and including galvanized wire dome grating.

Where vent pipe penetrates the roof slab; roof finishes and waterproofing material must be carried up around the pipe and must be closed with vent cap to prevent water penetration, all to the approval of the Engineer.

Fire fighting in the building is achieved by a wet riser system and in certain locations by portable fire extinguishers as shown in approved shop drawing.

Rain water is collected from roof and discharged to any nearby outlet as shown on approved shop drawing.

16.2.1 Drainage and Drain system

The external pipes shall be made of un-plasticized polyvinyl chloride (U.P.V.C.) from approved made unless otherwise noted according to the approved shop drawings.

The internal pipes shall be made of polyvinyl chloride (P.V.C.) or propylene (P.P) from approved

made unless otherwise noted according to the approved shop drawings. Pipes shall be laid in position by means of leveling instrument.

16.2.2 Water Distribution Networks

All the materials used in the main water distribution lines are galvanized steel pipes, grade B and approved made unless otherwise specified. All the internal cold and hot water pipes will be galvanized steel grade B or Polyethylene pipes (Golani system) as indicated in the drawings and bill of quantities, all per specifications and engineer's approval.

All the underground pipes shall be galvanized steel coated with bitumen and wrapped with insulation tape as directed by the engineer unless otherwise specified.

Where pipes emerge through walls, floors or ceilings; they should be passing through sleeves and insulated with tape over bitumen coats.

Wherever galvanized steel pipes are used for hot water, approved heat insulator should cover the pipes in addition to bitumen coats.

Firefighting pipes will be galvanized steel pipes and as in the approved shop drawings.

16.3 Pipe Installation

All piping shall be properly supported or suspended on stands, clamps, hangers, etc. of approved made. Supports shall be designated to permit free expansion and contraction while minimizing vibration. Pipes shall be anchored as directed by means of steel clamps securely fastened to the pipe and rigidly attached to the building structure. Screw threads shall be cut clean and true and joints made tight without caulking. Reducing fittings shall be used to change pipe size, and reductions to be made with eccentric reducers. Short radius fittings shall not be used.

Pipe work shall confirm fully of the following requirements:

- Piping shall be properly graded to secure easy circulations and prevent noise and water hammer. As much pitch as space conditions allow must be given. Capped dirt pockets to be installed at all riser heels, low points, and other places where dirt may accumulate. Allowance must be made for proper provision for expansion and contraction in all portions of pipe work to prevent undue strain in piping. Expansion joints to be installed as directed by the Engineer.
- All fittings such as elbows, tees, bushes, etc. shall be of best quality, foreign made or approved made [Class A] according to local standard with smooth interior surfaces. Approved screw unions or spherical joints shall be installed at trapped instruments, etc. and where else directed to permit easy connection and disconnection. Final connection to all equipment and fixtures shall be made in a manner that will permit the complete removal of any fixture or any piece of equipment without cutting of pipeline. If after the plant is in operation any system do not circulate quickly and noiselessly [due to trapped or air bound connections]. The Contractor shall make proper alternations in these defective connections. If connections are concealed in furring floors or ceilings, the contractor shall bear all expenses of tearing up and rebuilding construction and finish.
- All mains shall have a slope of not less than 5mm in 3 meters in direction of flow. All branches shall have a slope of not less than 1mm in 3 meters towards the main. All branches from mains shall be connected at the angle of 45 if possible. Each piece of pipe and each fitting shall be carefully inspected on the inside to see that there is not defective workmanship on the pipe or obstructions in the pipes or fittings. Joints in all threaded piping shall be jointed using red oxide lead and boiled in.
- Straight elbows, bushing, long screws or bull head tees shall not be installed, and all offsets shall be made with fittings. Pipes shall not be bended at any time.
- Pipe work shall be installed in manner to allow for ease of air escape and system draining. It shall be endeavored to obtain this naturally by gravity. However, where conditions don't permit it an automatic air vent shall be installed at all air pocket locations and drain gate valves shall be supplied and installed at all low points and risers legs or as shown on

drawings.

Before turning the project over to owner, system shall be thoroughly flushed of all dirt and foreign matter and the contractor shall thoroughly disinfect the entire water system including underground mains.

Pipes material is galvanized steel “blue sign” local made “class A”.

All pipe fittings such as elbow, tee, reducer, union, etc. shall be galvanized forged steel of the same quality of the pipe. Pipes and fittings shall be suitable for threaded connections

The Contractor shall provide suitable and substantial hangers and supports for all piping works.

Piping shall be carried by pipe hangers supported by concrete insets. In general supports for pipes shall be not more than 2.5m apart for 2” and smaller pipes according to the conditions of the job and directions of the engineer. Copper piping shall have hanger every 1.5 meter.

All vertical piping will be supported by heavy pipe clamps resting on the building structure. No piping shall be hung with other piping and all hangers shall be of heavy construction suitable for the size of supported pipes. All horizontal pipes shall be supported by split ring hangers of malleable iron provided with solid rod and nuts to maintain adjustable height.

All vertical pipe line passing up through the building shall be hung from each floor of the building. Malleable iron clamps of suitable size and bolted around the pipes shall be used for these supports.

These pipes shall be secured midway between the floor and the ceiling of each story by means of malleable iron, solid hangers around the pipe and fastened to adjacent walls by means of inverted bolts cast in concrete walls. Anchors shall be separated and independent from all hangers and supports.

16.4 Valves

Hand valves, float valves and check valves shall be of an approved make and shall be furnished and installed as shown on the drawings or as directed during construction.

The Contractor shall include for the finishing; the required valve tag and a schedule of valves with a schematic drawing showing position of each. The drawing shall be glazed, framed and hung in the machine room.

16.5 Floor Drain

Floor drain shall be obtained from an approved make P.V.C. 4”/2” minimum water seal, complete with chrome plated duty strainer tightly sealed to drain body. All 2” P.V.C. drain pipes are connected to floor trap by rubber sealed record fittings.

16.6 Roof Drain

Each roof drain shall be of P.V.C. constructed with built in trap, having an integral flange and wire dome type strainer, fixed by screwing into the drain body. Rain drain shall be installed as shown on drawings.

16.7 Storage Tanks

Water tank used is P.E approved make class A with lockable cover. The tank capacities will be as mentioned in the bills of quantities and as shown in the drawings.

The installation of the water tank must be carried out according to the drawings, manufacturer's instructions i.e. (tank foundation, mechanical float valve, valves, fittings, vent pipe, overflow, drain, connections and the required accessories) and as supervisor engineer instructions.

16.8 Packaged Domestic Water Booster Set

Packaged water booster set shall be located as specified and shall comprise all those items of equipment or component parts necessary to form a fully operational booster set as described in this Specification and the Equipment Data Sheets, and meet the requirements of the local water authority.

All pipe work, fittings and components shall be approved for the use of potable water and shall have a minimum test pressure rating of 1.5 times the closed valve head of the booster set under the supervision of the Engineer.

The booster set shall be supplied to site complete with General Arrangement Drawings and full wiring diagrams.

The booster set shall be mounted on a purpose made steel frame with adequate anti-vibration mounts and flexible couplings to prevent transmission of vibration to the building structure or service pipe work.

The booster set shall have 3 pumps arranged as lead (No. 1 pump), support (No.2 pump) and support (No.3 pump).

Automatic changeover relays shall rotate the duty pump every pumping cycle.

The booster set shall be designed, manufactured and installed for operation from an electricity supply system of 415/240 volts and 50Hz type TN-S.

Pumps

The pumps shall be vertical multistage in-line high efficiency type.

The pump body shall be cast iron with stainless steel shaft and stainless steel or gunmetal impeller fitted with mechanical tungsten carbide faced seals.

The pumps shall meet the design duty at a maximum speed of 48rev/s.

Motors

Electric motors shall comply with the requirements of the attached Schedules.

Motors rated up to and including 10 kW shall be started direct-on-line, ratings above 10 kW shall be star-delta started.

Hydraulic Accumulator

An integral hydraulic accumulator shall be fitted.

The hydraulic accumulator shall be a steel shell type with an internal diaphragm to BS 6144.

Pipe work and fittings:

All pipe works and fittings shall be galvanized steel class-B

Check valves up to 54 mm diameter shall be bronze/gunmetal to BS 6282: Part 1, with soft seats.

Check valves over 54 mm diameter shall be bronze/gunmetal to BS 5154 with soft seats.

Gate valves shall be bronze solid wedge disc type to BS 5154 Series B.

Drain valves shall be 15 mm diameter gunmetal 'lock shield type BS 2879.

Connections between the booster set and the system piping, the inlets and outlets to the pumps, and the hydraulic accumulator shall be flanged to BS 4504.

Gate valves shall be fitted to the suction and discharge of each pump, to the accumulator connection and to all gauges, pressure switches etc.

Check valves shall be fitted upstream of the gate valves on each pump discharge.

Drain valves shall be fitted on the discharge header and on all sections of isolated pipe work.

Controls

Each pump shall be controlled by an electrical 2 position pressure switch with a Scale range to cover a band of at least one and a half times the specified values.

The pump manifold shall be fitted with a system pressure gauge scaled in bars and be accurate to 2% of scale width throughout the range, the gauge scale range shall be at least 1.5 times the system closed head pressure.

Where suction tanks are supplied as part of the booster set package, low level pump cut-out switches shall be installed. Where break tanks are supplied by others terminals shall be provided in the control panel for connection to low level pumps cut-out switches by others.

Volt-free contacts shall be provided for remote monitoring of all control functions. Contracts shall be rated SA at 240V a.c.

All control equipment and instrumentation shall be installed so that there is adequate clearance for removal of all such items and that all wiring connections can be visibly inspected without removing the item.

Control Panel

Control panels shall be set-mounted and suitable for a prospective fault current of not less than 25kA unless otherwise specified.

Enclosures shall be suitably constructed from mild steel plate, which shall be thoroughly degreased, cleaned and rinsed prior to the application of a zinc phosphate coating, rinsed again and then epoxy powder coated. Doors shall be sealed with neoprene tube to give a degree of protection not less than P54 to BS 5420.

A suitably rated main incoming isolator shall be provided, interlocked with the door, to isolate all incoming supplies including auxiliary and control circuits. Isolator terminals shall be fully shrouded against accidental contact. All door mounted components shall be fully shrouded and individually labelled. The labels shall be fixed with chrome plated round headed screws.

The incoming supply shall be protected with a suitably rated multi-pole RCD Circuit-breaker with a trip current of 30 mA.

Identification labels shall be of engraving laminate with black letters of white background, except warning labels which shall have a yellow background.

Power and control wiring shall be to the IEE wiring regulations. The Sub-Contractor shall provide calculations to confirm that this requirement has been met.

Each starter shall have its own control supply, separately fused downstream of the main protective device and fitted with fuse failure indicators.

Finish

The complete booster set shall be painted 2 coats of primer and one coat of full gloss stove enamel to BS 4800 and BS 38 IC.

16.9 Manholes and Chambers

16.9.1 General

All chambers and manholes will be supplied by the Contractor according to drawings, specifications, bills of quantities and Engineer's instructions.

Work shall include excavation, backfilling, concrete base, hard-core installation, reinforced concrete cover slab, benching, internal rendering, external bituminous insulation, internal epoxy protection painting if notified in the bills of quantities, etc.

16.9.2 Construction of Manholes and valve Chambers

All manholes and chambers shall have reinforced-concrete bases. The Contractor shall construct all manholes, chambers, and special structures including transition chambers and outfall structures as indicated on the Drawings and herein specified.

Manholes, chambers, and special structures shall conform in shape, size, dimensions, materials, and other respects to the details indicated on the Drawings or as ordered by the Engineer.

Manhole and chamber cover slabs shall be either pre-cast or cast in place reinforced-concrete as marked on the Drawings. The cast iron frames and covers for manholes and chambers shall be brought with grade so that to sustain the indicated load.

Manhole walls (rings) and cover slabs shall be either pre-cast or cast in place reinforced-concrete. In pre-cast construction; rubber o-rings are to be placed in all joints except for the joint between the cast in place roof slab and the top wall ring. In general, the top level of manhole cover slab shall not be in any how lower than the level of cast iron cover by 30cm.

Benching of manholes must be smoothly curved and semi circular of diameter equivalent to inlet and outlet pipes. Benching should be rendered and plastered perfectly smooth, inclined in the manhole to 2cm minimum.

Manholes over 1m deep shall be supplied with Cast Iron steps well anchored to the concrete walls at a spacing of 30cm.

Drop manholes must be constructed if the difference in depth between the inlet and outlet pipes exceeds 60cm.

16.9.3 Formwork of Valve Chambers

The Contractor shall be responsible for the design and stability of the formwork of the chambers. The Contractor shall submit a full program of work and safety indicating the various phases for the erection and removal of forms and the manner in which he intends to execute.

The contractor shall take the safety measures in order to avoid any corresponding incident and he shall hold the responsibility of pit protection during the construction of the chamber.

16.9.4 Cleaning

All manholes and valve chambers specified under this section shall be cleaned of any accumulation of silt, mortar, debris or any other foreign matter of any kind and shall be free of any such accumulations at the time of final inspection.

16.10 TESTING

16.10.1 General

The Contractor shall submit to the Engineer prior to the date of commencement of the tests his proposed test procedure. The procedure method and points of measurement and the method of calculation, shall be approved by the Engineer before any test is carried out.

The Contractor shall supply skilled staff and all necessary instruments and carry out any test of any kind on a piece of equipment, apparatus, part of a system or on a complete system if the Engineer requests such a test for determining specified or guaranteed data, as given in the Specifications.

Any damage resulting from the tests shall be repaired and/ or damage material replaced, all to the satisfaction of the Engineer.

In the event of any repair or any adjustment having to be made other than normal running adjustment, the tests shall be voided and shall be recommenced after the adjustment or repairs have been completed.

The test shall not be made void due to circumstances beyond the contractor's control.

All testing, balancing and final adjustment shall be in accordance with the provision of the applicable BS Code of technical practice.

16.10.2 Water Supply Systems

All water supply piping shall be tested under hydrostatic pressure of not less than working pressure for 24 or hydrostatic pressure of not less than 1.5 working pressure for one hour as directed by the supervisor engineer. This test should be applied to separate lengths of pipe work before final connection of equipment and appliances but after all piping is completed. Systems shall also be flushed.

Test shall be completed and approved before pipes, valves and fittings have been concealed.

16.10.3 Gas Network

A - Copper Pipes Used for Gas:

The pipes should be round and smooth, completely clean, free of defects and surface oxidation and to be trimmed off vertically so that the roundness of the cross section does not be affected.

The supplied pipes should be of brand name and clearly showing the manufacturer brand, Standard No. in addition to the type and size of such pipes.

The contractor has to provide a certificate issued by recognized laboratory proving that the pipes comply with the specifications, otherwise the engineer is entitled to take samples from the supplied pipes for testing at the expense of the contractor.

B - Pressure to Cut Copper Pipes:

Fittings should be suitable for connections of copper pipes and comply with the British Standard (BS 864 PART2).

Fittings should be made of copper or copper alloys which resist chemical corrosion.

Fittings must pass the hydraulic pressure test equal to 2.1 N/mm^2 with no leakage.

Fittings must pass must pass the porosity test according to British Standard (BS 864 PART2).

C – Connection of Copper Pipes by Welding:

Both ends of the two pipes should be cleaned properly with steel wool or glass paper, wiped from any particles and painted with welding agent (FLUX) before the welding process.

The process of welding should be performed either by silver ring or welding tin according to the special specifications. If is not explicitly specified which method to be followed, the contractor has the right to choose the appropriate one of those methods.

1. Silver Ring Method:

This method is used to joint a pipe with a fitting so that the pipe end as well the fitting are heated till the silver ring inside the fitting melts and flow to fill the gap between the pipe and the fitting.

2. Welding Tin Method:

This method is used to joint a pipe with a fitting or a pipe to pipe so that the ends of the two

pipes are heated, then make the welding rod touches the area of welding till it fills the gap between the pipes.

D- Gas Manifold

Gas manifold shall be of size and capacity as shown on the drawings. Manifold shall be of red brass with the possibility of replacing any cylinder without having to interrupt the service.

Manifold shall comprise cylinder isolating valves, change-over valve for transferring from one bank of cylinders to the other, pressure reducing valve and pressure relief valve.

Manufacturers shall be an approved local vendor.

E- Gas Pressure Regulator

Pressure regulator shall be constructed of a pressure cast aluminium alloy body with an internal relief valve of brass construction. Valve seats shall be made of a synthetic rubber or leather and shall be so designed that they may be replaced without disconnecting the regulator from the line. Regulator shall be provided with vent openings and pressure gauge on low side of regulator. Regulator shall be Rockwell Manufacturing Co. No.107-2 or approved equal.

The regulator shall be as required by the local gas vendor but shall be purchased and installed by the Contractor.

F- Vent Cap

The Contractor shall provide and install Peck vent cap as required and approved by the local gas vendor.

G- Gauges

Pressure gauges shall be of the Bourdon tube type. Working parts shall be of corrosion-resisting metals. Dial diameter and scale numerals shall permit easy reading from floor. Range shall place working pressure at or near the middle of scale. Dial face shall be calibrated in increments of one-inch water with a range equal to twice the maximum operating pressure. Dial diameter of pressure gauges shall be of the size and range as specified under the required service.

H- Alarm Gong

Push-button operated alarm going to actuate solenoid valve installed on gas manifold. Alarm gong must be supplied complete with push-button electric connections and solenoid valve.

I- Tests

Piping shall be tested in the presence of and to the satisfaction of the Engineer. Air pressure for testing shall be at least five times the expected service pressure, but not less than five pounds per square inch (indicated by a ten inch column of mercury) shall be applied. The pressure test shall be held on the system for a period of sixty minutes, with mercury column showing no detectable drop in pressure.

16.10.4 Drainage and Waste Systems

These systems shall be subject to a water test prior to being covered and also tested for water tightness after backfilling.

On any section of the pipe under test the head of water applied shall not be less than 3.00 meters and not greater than 6.00 meters. Tests shall be maintained for 20 minutes, and any defects shall be rectified and the test reapplied to the complete satisfaction of the Engineer.

16.10.5 Final Testing

In addition to the above, final tests shall be carried out as directed by the Engineer just before final completion of the Works and during the maintenance period.

16.11 PLUMBING FIXTURES

The following fixtures shall be supplied with cold and hot water by pipes not less than 1/2".

1. Supply and installation of wash basin, porcelain approved made class "A", with chrome plated cold and hot water mixer or faucet, size 1/2" of approved manufacturer such as including PVC trap connected with over flow and with the floor trap by plastic P.V.C. pipe 2". The work shall include supply and install soap holder, chain and rubber plug, angle valves, hoses and all needed accessories. Height of basin is 80 cm from the finish floor level.
2. Supply and installation of porcelain W.C. including internal S or P Siphon approved made class "A". The price includes plastic flushing cistern tank, plastic W.C. seat cover of heavy duty, porcelain toilet paper holder, chrome plated angle valve 1/2", chrome plated flexible hoses 1/2", flushing spray hose, and all needed accessories. The W.C. should be connected with the 4 inch P.V.C. main sewage pipes and the flushing tank to be connected to the main water line by 1/2" galvanized pipe or otherwise specified. European W.C. bowels shall be fixed to floor by cadmium screws and tightly grouted.
3. Hand Spray (Hose Bib) shall be complete with CP angle valve, 1-meter metal, flexible tube, hand spray, wall hook etc. The metal flexible tube shall be provided with transparent plastic cover. Hand spray to be provided to the right side of each WC for washing purposes.
4. Supply and installation of stainless steel kitchen or fire clay porcelain including the supply and fixation of chrome plated mixer of approved quality connected to cold and hot water mainline by 1/2" galvanized steel pipes or otherwise specified including PVC trap connected with over flow and with the floor trap by plastic P.V.C. pipe 2". The work shall include supply and install chain and rubber plug, angle valves, hoses and all needed accessories.
5. Laboratory Sink white glazed fireclay sink of 500x400 x250 mm, Italian made or approved equivalent (Grade/A) for laboratory with cold water taps no:2. Complete with all connections, and fittings. Sink shall be single bowl and drainer as specified or shown on the Drawings. The sink shall be provided with, chain stay hole and overflow and with back splash end. The sink shall be complete with the following trim and accessories: -
 - 40-mm dia. chrome plated waste with stainless steel grating and chain stay and plug.
 - 40-mm plastic bottle trap with extension tube.
 - Flexible plastic tube for overflow connection.
 - 15-mm diameter chrome plated angle valves with flexible copper tube
 - 15-mm diameter chrome plated

Immediately after the Contract has been awarded; the Contractor shall prepare detailed drawings showing exact position of all plumbing fixtures, position, type and size of all water pipe work, drainage, and piping clearly indicating the proposed fittings. These drawings, when approved by the Engineer, shall be used for ordering purposes.

16.12 FIRE FIGHTING SERVICES

The firefighting services shall be executed as shown on the drawings. All firefighting components shall be approved by the Local Civil Defense Department.

16.12.1 Pipework

All pipe work shall be galvanized seamless steel to BS 1387 heavy grade. Pipework with screw fittings shall be supplied with screw and socket ends. Pipework for gas and arc welding, where permitted by the Engineer, shall be supplied with plain ends, be veiled for butt welding. All pipework and fittings shall be to NFPA 14.

For pipe work installation, hangers, welding, etc., details refer to previous sections of these Specifications.

Under tiles, steel pipe work shall be protected against corrosion by two layers of hessian and tar to the Engineer's approval.

Valves, strainers, etc. shall be as specified previously.

16.12.2 Fire Hose Cabinet

Fire hose cabinets shall be installed where shown on the drawings. The fire hose cabinet shall be automatic swinging recessed type of dimensions 800x800x250 mm. Hose reels shall be in accordance with BS 5274.

Where specified, the rubber fire hose shall be 1" x 30m smooth seamless reinforced with double synthetic textile yarns layer capable of withstanding a working pressure of 20 bar and a bursting pressure above 50 bar. It shall be complete with 1" nozzle.

Where specified the hose connected to the landing valve shall be 2.5" x 30m long circular woven synthetic fibre and root proof yarn capable of withstanding a working pressure of 16 bar and a bursting pressure of 50 bar. It shall be provided with suitable male and female instantaneous coupling so that it can easily be fixed to the landing valve at one end and to a jet/spray nozzle at the other end.

The hose reel shall be equipped with shut-off valve for connecting with pipe work.

The hose nozzle shall be chrome-plated brass, JET/SPRAY/SHUTOFF nozzle.

The cabinet shall be heavy steel construction finished with red colour paint labeled "FIRE HOSE REEL" in English and Arabic.

The fire hose cabinet shall include a dry powder fire extinguisher of 6Kg ABCE type as specified hereafter.

16.12.3 Portable Fire Extinguishers

The Contractor shall supply and install portable fire extinguishers in the positions shown on the drawings.

All fire extinguishers located outside hose reels cabinets shall be complete with wall mounting brackets, and placed inside recessed type, red colour cabinets clearly marked (Fire Extinguisher).

Where fire extinguishers are located within fire hose cabinets they shall be placed on the floor of the cabinet.

Dry powder fire extinguisher shall be ABCE type 6 Kg capacity with a rugged all brass operating valve, large size operating lever, full vision pressure gauge, discharge hose and heavy duty drawn steel cylinder with hard, scratch resistant finish.

CO₂ gas fire extinguisher of 6Kg capacity with a rugged all brass operating valve, large size operating lever, full vision pressure gauge, discharge hose and heavy duty drawn steel cylinder with hard, scratch resistant finish.

16.12.4 Inlet Breaching Valve Connections

Inlet breaching valve connections shall have bronze body with 75mm (3 inch) nom. dia. threaded bottom outlet and two (2) nos. threaded front inlets with individual, internal drop flaps, extension

nipples, chrome plated brass, rectangular escutcheon with lettering “Stand pipe – Fire Department Connection”, 1nos. 75mm (3 inch) nominal diameter, instantaneous male inlets with chain and cap etc. complete.

16.12.5 Fire Fighting Pump set

The fire fighting pump set shall consist of two main pump, and one jockey pump, pressure vessel, and control panel.

The capacity of each pump shall be as shown on Drawings and Bill of Quantity.

The pump set shall be provided with motors, starters, controls, pressure gauges, accessories and all other components for the proper operation.

The pressure vessel shall be of capacity 50 litre, and suitable for working pressure of 10 bar.

The pump set shall be mounted on concrete foundation extended 300mm above finished floor level. The fire pump set components, controls and operation shall be as detailed for cold water booster pump with the exception of the following:

- Impeller shall be of bronze construction.
- The pump set shall operate under the control of pressure switches.
- Standby pump shall be diesel engine direct driven.
- The engine may be of the air-cooled type and shall automatically start on demand if the duty pump fails to maintain system pressure.
- The standby pump shall be manually switched off. The engine exhaust pipe shall be insulated and arranged to discharge outside. Multi attempt relay shall be included in control panel to allow at least 3 attempts for the engine to start.
- The control panel shall include an earth leakage sensor with hooter, mute push button and indication lamp.

The fire pump set shall be constructed to Local Civil Defense requirements and a certificate stating this shall be provided with the pumps.

16.12.6 Pre Commissioning Cleaning

Tubes and all items of equipment shall be delivered, stored and maintained in storage with their open ends effectively plugged, capped or sealed. All fittings, valves and sundry items shall be stored in clean bins or bagged and stored in suitable racks. All such stored items shall be maintained under weatherproofed cover to be supplied by the Contractor until they are ready for incorporation in the works. Particular care shall be taken to ensure that electrical equipment and components are kept clean and dry.

Before installations are handed over or subjected to the inspection and tests, the entire installation shall be thoroughly cleaned, both internally and externally.

All fire protection installations shall be flushed out with clean water. During the flushing out provision shall be made to exclude any items of plant, which could be damaged by the cleaning operation. The entire operation shall be carried out to the satisfaction of the Engineer.

16.12.7 Testing

All pipe work shall be pressure tested as detailed in Section 15 of these Specifications.

16.12.8 Painting

All pipe work for fire protection services shall be given one coat of rich primer and two coats of 'Post Office Red' paint after installation and pressure testing.

16.12.9 Labels And Identification

All items of Fire protection system shall be labeled and identified according to the requirements of local Civil Defense Authority.

17 –VENTILATION AND AIR CONDITIONING

17.1 Scope

The works covered under this contract include all the supply, install, test, commission and maintain in good operating condition of the complete ventilation system described in this specification and shown on the drawings in accordance with the drawings, schedule and specification including but not limited the following: -

- To check the design and to undertake the responsibility of giving the design conditions in the occupied areas.
- To provide power supply to the individual AC Units.
- To provide complete control wiring.

17.2 Preliminaries

The specification and drawing shall be interpreted in accordance with the guidelines of the codes of practice of the CIBSE and ASHRAE Standard where such codes are relevant. Any Detail not shown or specified but necessary for the proper installation and operation shall be included in the work. The contractor shall set sleeves for pipes and ducts accurately before the concrete floors/walls are poured.

17.3 General Specification

Design Elements

The installation is based on the following design conditions. The capacities and dimensions given in the specifications or drawings will be considered as the minimum to be accepted.

- Outdoors design condition: 115oF DB and 84o WB
- Indoor Design Condition:
 - Temperature 76 + 2o F DB
 - Relative humidity 50 + 5% RH
 - Noise Level 35 NC
 - Power Supply: - 380/50/3ph or 220/50/1ph

Operation And Maintenance Instructions

Three sets of operation and maintenance manual of the ventilation, equipment shall be furnished and Handover to the client. The contractor shall also to furnish the name and telephone numbers of manufacturers in order to expedite the further replacement of the parts.

17.4 Exhaust (Extract) Fans

Fan casings shall be of rigid and airtight construction, manufactured in materials resistant to corrosion from the operating environment and conditions. Fans shall be tested to BS 848 Parts 1 and 2.

All fans shall be statically balance dynamic balancing shall be included where scheduled.

Fans final duties shall be verified taking into account certified resistances of system components.

Where air filters are included in a system the fans shall be selected to deliver the design air volume against the system resistance including dirty filters.

Fans and motors shall be suitable for continuous operation and any start/stop programmers specified. Motor and fan bears shall have a minimum design operational life of 40,000 hours with one start and stop per hour.

All cases fan assemblies shall be resiliently mounted to prevent vibration transmission to elements which they are fixed. Centrifugal fan assemblies with indirect drives shall have fan and drive motor mounted on a common and continuous rigid sub-frames resiliently mounted.

Fan scrolls and casings shall have drain plugs and inspection/cleaning doors where specified.

Flexible connections shall be made between the fan outlet and the unit casing in woven fire-retardant material.

Lubricators shall be provided to all fan and motor bearings (except sealed type where accepted or use), be extended if necessary to accessible positions, and have seal caps.

Rigid protective screens of woven steel wire and mesh shall be provided to all inlet and discharge opening for fans not protected by ductwork system connections.

Suspended fans shall be supported on a suspended sub-frame with vibration isolation provisions between the fan (and drive) and the sub-frame.

The assembly shall prevent significant movement of the fan relative to any ductwork system due to fan torque and thrust.

17.5 Mini Central Split Units

Each split unit shall consist of two parts assembled, tested and ready for operation:

- An outdoor condensing unit
- A decorative type indoor unit or ducted indoor unit.

The two parts shall be connected together with quick connections recharged and reinsulated refrigerant piping.

Outdoors Unit

The outdoor condensing unit 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 valves shall be located at the exterior of the unit. The compressor shall be of the welded hermetic type rotary/reciprocating with internal vibration isolations 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 crankcase 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 unit shall be housed in a weatherproof cabinet.

Indoor Unit

The indoor unit shall be exposed decorative type calling suspended/wall/floor mounted according to the drawings and Consultant's approval.

The unit shall be fabricated from galvanised steel sheet and shall be internally insulated. The cabinet shall be preprinted with baked enamel paint and provided with adjustable plastic grilles. The fan shall be centrifugal, direct driven, double inlet type with two impellers.

The impellers and scrolls shall be made in shockproof material to guarantee maximum stability during transport and installation. The impeller shall be having airfoil blades.

The motor shall be permanent split capacitor type single phase and shall be totally enclosed. The unit shall be complete with remote control kit consisting mainly of three speeds and off switch and a thermostat.

18 –ELEVATOR WORKS

18.1 GENERAL SPECIFICATIONS

The design and installation construction shall be in accordance with the European code for elevators.

General Information

- 1- Installation conditions:-
 - a -Height above sea level
 - b -Ambient temperature 0 °C (min) 40 °C (Max)
- 2-Construction / Building type; Steel Structure
- 3- Lift Shaft construction; Steel Structure

General Electrical Requirements

1. Power supply 220/380 Volts, 3-phase 50 Hz.
2. All electrically operated equipment shall be so designed that it will continue to function without damage to itself or otherwise, if the voltage or frequency varies within the following tolerances:

Voltage:	plus or minus ten percent (10%).
Frequency:	plus or minus six percent (6%).
3. All electrically operated equipment shall be suitable for continuous and prolonged operation in the prevailing ambient temperature. Allowance shall be made for local rise in air temperature due to the equipment.
4. A three-phase electrical supply for the lift machinery and controls will be made available in the machinery room, and a single-phase supply will be provided adjacent to the midpoint boxes in the lift shaft for the lighting circuit and socket outlets.
5. The shaft and machine room electrical installation shall be executed in heavy duty self-extinguishing plastic conduit, or multicore cables with the aforementioned properties.
6. Traveling cables shall be of the flat PVC protected type.
7. Electrical wiring for operation and indicator circuits shall be of copper, minimum cross-section 1 mm² and self-extinguishing PVC insulated 500 V.

Tests on Site

The contractor shall provide all instruments and apparatus required for the tests on site and he shall carry out the following tests in the presence and to the entire satisfaction of the supervising Engineer:

1. Insulation tests on all wires and cables with a 1000 volt meager and resistance tests of the conduit system forming part of the contract.
2. Operational and functional tests on all power components and safety devices
3. Stationary load tests: in this test the car shall be loaded with weights equal to 150% the rated load. After 30 minutes the elevator shall not show any sign of damage or permanent set.
4. Speed test shall prove that the elevator speed average variation value will be contained within -5% between up and down runs.

18.2 TECHNICAL FEATURES

18.2.1 Hoisting Machinery

Lift machine shall be adequately isolated from the main building structure by means of anti-vibration rubber pads.

The lift machine shall be of the worm geared traction type with a traction sheave and brake. The reduction gear assembly shall be of the self-lubrication type enclosed in a cast iron oil-tight casing having an adequate lubrication oil bath capacity. The brake shall be spring applied, magnetically released by a D.C electromagnet, self-cooling and capable of holding the car securely under maximum speed and load conditions in the event of electric power supply interruption.

Under such conditions the brake shall be designed for automatic and instantaneous application. The brake springs shall work in compression. Means shall be provided for the manual release of the brake in order to allow manual winding of the unit in emergencies. The brake emergency release must be self-resetting.

The traction sheave shall be designed to give maximum adherence and long rope life. It must be flange coupled and with grooves of semicircular section with recesses. The diameter of the pulleys shall in no case be smaller than forty (40) times the overall diameter of the cables.

The elevator shall be VVVF (Variable Voltage Variable Frequency) AC motor specially designed and constructed for elevator purposes. The motor shall be smooth running on phosphor-bronze bearings having a high starting torque and with its starting current limited to 3.5 times the nominal value. The motor shall be projected for operation the maximum ambient temperature of the site. It shall be tropicalized and protected according to IP21 Standards.

18.2.2 Guide Rails

T-section rails of quality steel shall be provided as guides for cars and counterweights. The car guide surface shall be accurately finished. Steel splice plates of adequate strength shall be used to connect the rails together and in proper alignment by means of location slots. The guide rails and their fixings shall be capable of withstanding the sudden application of the safety gear under maximum load conditions.

18.2.3 Counterweight

The counterweight shall be designed for smooth and economical operation. It shall consist of a structural steel frame fitted with the necessary cast iron sub weights. The weight of the counterweight shall be equal to the total weight of the car plus approximately 45% of the contract load.

Sliding type guide shoes shall be fitted at the top and bottom of the counterweight.

The sliding shoes liners shall be renewable and smooth running.

18.2.4 Hoisting Ropes

The hoist ropes shall be of special quality steel of suitable size the construction and number especially designed for lift duty and having a factor of safety at least equal to that specified in D.P. R1497 or approved equivalent standard.

The hoist ropes shall be of SEALE LAY construction having six lays.

The solder method of attaching the ropes to the car and counterweight shall be used.

Independent adjustment shall be provided for each rope.

18.2.5 Safety Gear

A mechanical safety gear shall be mounted underneath the platform, in order to stop the car in case of excessive downward speed or failure of one more suspension ropes or their fastening. In case of tripping a switch shall disconnect power to the motor and brake control circuits.

The safety gear shall be capable of securely holding the car under maximum load and governor tripping speed conditions.

The safety gear shall be of the instantaneous or progressive type in accordance with local standards requirement and design for automatic release in the up-direction whenever the safety has been actuated.

The instantaneous safety device shall consist of heavy jaws steel rollers, a lever assembly and other accessories to force the jaws and roller against rails.

18.2.6 Speed Governor

The governor shall be accurately adjusted and sealed to trip at a speed equal to that specified in D.P.R. 1497.

Operation of the governor on downward over speed shall, in addition to tripping of the safety gear, open a switch disconnecting power to the motor and brake control circuits, these circuits shall also open in the upward over speed condition .

Restoration of power shall not be possible until the safety gear and the governor switch have been manually reset.

For the instantaneous type safety gear:

- The speed governor rope shall be of minimum 6 mm diameter and kept in correct tension by an adequate pulley weight in the lift pit.
- The speed governor rope sheaves shall be of minimum 250 mm diameter

18.2.7 Buffers

Spring buffers shall be designed according to the safety gear tripping speed and installed in the pit under each car and counterweight to allow smooth stopping in case of emergency.

18.2.8 Lift Car

The car frame shall be manufactured from robust structural steel members properly braced and securely, fastened together.

The car walls shall be made of heavy gauge pressed steel lined with stainless steel and provided with stainless steel hand rails.

Car doors shall be heavy gauge pressed steel lined with stainless steel.

A safety edge device extending the full height of each door and projecting beyond the front edge of the door panels shall be provided such that if this device touches an obstruction it shall automatically cause the car and landing doors to open.

Kick plates, butt straps and accessories shall be made of silver anodized anti-corodal.

The car platform shall be made of 12 mm steel sheet, suitably reinforced and covered with a soft and hard wearing multi-layer fire-resistant material.

Lighting shall be indirect by a minimum of two fluorescent lamps.

The ceiling shall be of 2 mm baked enamel steel sheet, suitably reinforced to withstand the equivalent load of two persons.

Ventilator fan shall be provided in the ceiling with a suitable air distribution device.

A single phase induction motor shall be used for this purpose. The fan shall be of the silent running type.

The car construction shall be designed for the retaining bolts and screws to be hidden on the inside

The car shall be completely isolated from its frame by means of anti-vibration rubber pads.

18.2.9 Car And Landing Door Operator

Door on the car and at each hoist way landing shall be operated quietly and smoothly by an electric operator of variable speed which shall open and close the car and hoist way doors simultaneously.

The car door shall be provided with an electrical contact to prevent lift movement away from the landing unless the door is in the closed position.

Each hoist way door shall be equipped with a positive electromechanical interlock and auxiliary door closing device so that the lift can be operated only after the interlock circuit is established.

In case of power interruption or failure of the operator, it shall be possible to open the doors manually from within the car.

The door operation shall be controlled by a solid state infra-red light emitter photoelectric cell safety device. The door shall re-open immediately should the light beam be interrupted and remain completely open for a predetermined time after the restoration of the beam.

The door operator is D.C. motor operated, and has safety electronic edge.

The car and landing doors suspension shall be by bearing mounted steel guide rollers having grooves elasticized with a composition resistant to wear and attacks by atmospheric elements. These rollers shall run on semi-circular steel guides. A device shall be provided to prevent the doors falling down in the event of the rollers damage.

The car and landing doors leading edges shall be fitted with full length rubber or plastic strips to absorb shocks and avoid gaps between the doors in the closed position.

18.2.10 Landing Doors and Frames

Landing doors panels shall be made of heavy gauge pressed steel lined with stainless steel.

The landing doors frames shall be of heavy gauge pressed steel lined with stainless steel.

18.2.11 Electrical Controller

The controller shall house contactors, relays, timing devices, transformers and all apparatus associated with the control of lifts in the machine room.

The controller shall have a robust steel frame vertically mounted on rubber pads.

All power contactors shall be electro-magnetically operated and mechanically interlocked to prevent the contacts for one direction closing while the contacts of the other direction are closed. At least two contactors shall be used to control the lift operation in each direction. The circuit shall be designed to prevent the operation of the lift in the event of failure of one contactor. The power contacts shall be silver contacts.

The relays shall be of the industrial heavy duty type having solid silver contacts.

The control system shall operate from a rectified A.C. supply giving a maximum of 80/110 Volt D.C. by means of a Transformer and silicon Rectifier.

The control system must be from solid state components controlled by microprocessor, and full collective for bed and passenger lifts.

18.2.12 Control System And Electrical Equipment

The operation of the lift shall be by simplex down collective method.

Each landing shall be provided with a control station containing one illuminating call push button, showing indicators & directional arrows.

The car shall be fitted with a control station having command push button corresponding to the floors served, "STOP" and "ALARM" buttons, and one "FAN" switch, one door open & one door close buttons.

Landing and car control stations faceplate shall be made of silver anodized anti cordial.

An illuminated car position indicator shall be provided in each car and at all landing entrances which will indicate the landing at which the car is stopped or passing.

18.2.13 Alarm System And Emergency Light

The alarm system shall include a push button in the car and a suitably located alarm bell.

The alarm circuit shall be fed by a sealed "Nickel-Cadmium" battery, kept charged by a trickle charger.

Also car shall have an emergency light fed by a suitable charger to serve for at least 1 hr before recharge.

18.2.14 Automatic Terminal Stops

Each lift shall be equipped with an automatic stopping device arranged to bring the car to a stop accurately at the terminal landing independent of the regular operating device in the car , final limit switches shall be installed in the hoist way, operated by the lift car and arranged to stop the car and prevent normal operation, should the car travel beyond the limit of the normal stopping device .

18.2.15 Automatic Leveling Device

Passenger lifts shall be equipped with an automatic leveling device that shall provide compensation for thermal expansion, elevator loading and normal rope stretch.

19 -FUEL INSTALLATIONS

19.1 Scope of Work

The works shall comprise all necessary items to provide the complete insulation of a fuel oil storage and distribution systems as generally described hereunder.

19.2 Fuel Storage Tank

The fuel storage tank shall be cylindrical type of capacity as indicated in the bill of quantities and drawings, underground, convers ends and shall be constructed from 6mm thick mild steel welded sheets to the size as indicated on the Drawings, and according to American Petroleum Institute Standard 650.

The tank should be anti-corrosion painted and bitumen coated in two layers with cloths.

The tank shall be provided with the following:

- One 25 mm screened air vent.
- One 65 mm fill- lines complete with isolation valve gunmetal cap and chain.
- One Oil contents pneumatic gauge with scale calibrated in liters capacity. Gauge mechanism to be housed in a weather- proof “clear vision” enclosure.
- Two 100 mm capped sockets to include purpose made brass dip rods. Rods to be calibrated in liters engraved onto the brass at not greater intervals than 100mm.
- One 25mm suction line from tank to daily fuel tank through feeding pump, complete with isolation valve and foot valve.
- One 20mm return line from daily tank over flow.
- One 60 × 60 × 60 cm manhole, fitted with a lid raised and securely fixed by bolts and gasket to provide a liquid and vapor tight joint.
- One Caged ladder shall be provided for internal access into the tank from the manhole entrance
- One Drain valve ø 1 "
- One Earth system

19.3 Fuel Supply System

The fuel supply system shall comprise of one main supply line. The supply lines from the tank to feed the pumps and a fire valve shall be installed on the feed line for each equipment.

19.4 Filters

Single type fuel filters shall be fitted on the outlet side.

The filters shall be line size, tested to 20.6 bar and shall have gunmetal body and covers, stainless steel internals with a stainless steel mesh element and be complete with brass drain plug. The elements shall be capable of filtration down to 100 microns.

19.5 Fuel Pumps

- GEAR TYPE
- Automatic nozzle, 3/4" X 12' hose 807C meter installed.
- Automatic nozzle

- Unit supplied with 220 VAC - 50 Hz motor
- Unit equipped with meter registering liters
- Nozzle Spout Hook
- 2" O.D. X 1" I.D. tank adapter
- Clear Bowl, 10 micron particulate filter w/ drain valve

19.6 Safety Testing

A nationally recognized independent organization for testing of products to ensure public safety shall carry out inspection and testing the fuel system. Such entity must be recognized and accepted by the Engineer.

The following guidelines must be considered during the testing:

- | | |
|---|----------------------|
| • Maximum pressure | 3 BAR |
| • Maximum flow rate | 3 m ³ /hr |
| • Maximum Recommended Viscosity of Pumped Fluid | |
| • Maximum ambient operating temperature | 66 °C |
| • Minimum ambient operating temperature | -26 °C |
| • Minimum Dry Vacuum | 12 Inches of mercury |
| • Minimum Suction Lift | 15 Feet for fuel |

19.7 Fuel Pipes

Pipes shall be black seamless steel to BS 1387 heavy gauge with black threaded malleable iron fittings for pipes 50mm diameter and under , and black steel seamless welding fittings for pipes above 50mm diameter .

20 –DESALINATION PLANT

The Reverse Osmosis (R.O) System Supplier shall assemble and furnish package type RO unit with nominal capacity of 5.0 m³/day potable water in according with the following specification.

Plant Capacity:

The plant shall be designed and produced according to operational requirements as follow:

Plant production rate:

Per day	5.0 m ³ /day
Per hour	0.16-0.2 m ³ /h
Design temperature	17 °C
Water recovery rate	30%
Required raw water flow	0.8-1.0 m ³ /h
Brine flow	0.84-0.8 m ³ /h

Packing Frame (Skid)

- Made of steel coated three layers.
- Thickness not less than 2 mm.
- The skid shall contain the following components
 - a. Primary pump
 - b. Cartridge filter vessel
 - c. High pressure pump
 - d. Electrical control panel
 - e. Pressure vessels
 - f. Flow meter
 - g. Pressure gauges

RO Membrane:

- Matches European Standers
- Membrane type : cross linked Fully Aromatic Polyamide composite
- Membrane diameter (inch): 4''
- Membrane area $ft^2 (m^2)$: 87 (8)
- Salt rejection %: 99.7 %
- Product flow rate gpd (m³/day) : 2400 (9.1)
- Operating limits:
 - Maximum operation pressure 600 Psi (4.1 MPa)
 - Maximum Feed Water Temperature 113 °F (45°C)
 - Maximum Feed Water SDI15 5
 - Feed Water pH Range, Continuous operation 2-11
 - Feed Water pH Range, Chemical operation 1-12
 - Maximum pressure Drop per Element 20 Psi (0.14 Mpa)
 - Maximum pressure Drop per Vessel 20 Psi (0.14 Mpa)

Pressure Vessel:

- Holds membrane elements
- Each vessel holds 1 membranes

- Made of Fiberglas FRP
- Design pressure 300 Psi at 120 ° (2.1 MPa at °C)
- Minimum operation temperature 20 °F (-7 °C)
- Burst Pressure 1800 Psi (12.2 MPa)

Pressure gauge

- Monitoring the {Feed water &brine water & Permeate water }
- Casing: Stainless Steel Glycerin
- Connection: 1/4" Back
- Pressure Range: 0-20 bar

Primary pump:

- Matches European Standards , type (Speroni or equivalent)
- Centrifugal primary feeding pump
- Power : 3/4 HP
- Flow rate : 1 m³/h @ 4 bar
- General data :
 - a. Plug: Stainless steel AISI304
 - b. Bearing: Tungsten carbide
 - c. Impeller: Stainless steel AISI304
 - d. Shaft: Stainless steel AISI304
 - e. Motor and cover: Aluminum Alloy
 - f. Base Plate: Cast iron
 - g. Diffuser: Stainless steel AISI304
 - h. Impeller sleeve: Stainless steel AISI304
 - i. Suction: Cast iron
 - j. Discharge: cast iron
- Operating conditions :
 - a. Ambient temperature up to + 40 °C
 - b. Maximum operating pressure 10 bar
 - c. Liquid temperature Normal -15 °C to +70 °C
 - d. Liquid temperature hot water -15 °C to +110 °C
- Motor insulation class : F
- Motor protection class: IP55

High Pressure Pump:

- Matches European Standards, type (Speroni or equivalent)
- Power : 1.5 HP
- Flow rate : 1 m³/h @ 13.5 bar
- Vertical non-self-priming multistage centrifugal pump
- Driven standard electric motor
- motor
 - Full-enclosed air-blast
 - Protection class: IP55
 - Insulation class: F
- General data :

Pump head	Cast iron
Plug:	Stainless steel AISI304
Bearing:	Tungsten carbide
Impeller:	Stainless steel AISI304
Shaft:	Stainless steel AISI304
Motor and cover:	Aluminum Alloy
Base Plate:	Cast iron
Top diffuser	Stainless steel AISI304
Inducer	Stainless steel AISI304
Cylinder	Stainless steel AISI304
Diffuser:	Stainless steel AISI304
Impeller sleeve:	Stainless steel AISI304
Suction:	Cast iron
Discharge:	cast iron
Coupling	Carbon steal

- Operating conditions :

Ambient temperature	up to + 40 °C
Maximum operating pressure	10 bar
Liquid temperature Normal	-15 °C to +70 °C
Liquid temperature hot water	-15 °C to +110 °C

Sediment Cartridges

- Accuracy: 5 micron
- Housing: 20" PPF
- Maximum water temperature : 125°F (52°C)
- Maximum pressure : 0.5 Mpa
- Reducing (Salt, Silt, Dirt, Rust Particles)

Multimedia Filter

- Dimensions 44"x8"
- Filled with suitable sand layers according to supervising engineer instruction.
- Automatic control valve
 1. Automatic backwash
 2. connection 1"
 3. in/out 1"

Carbon Filter

- Dimensions 44"x8"
- Filled with suitable carbon according to supervising engineer instruction.
- Automatic control valve
 1. Automatic backwash
 2. connection 1"
 3. in/out 1"

Limestone Filter

- Dimensions 44"x8"

- Filled with suitable Crushed limestone according to supervising engineer instruction.
- Automatic control valve
 1. Automatic backwash
 2. connection 1"
 3. in/out 1"

Electrical Valve

- Specification
 - Base orifice size 1.8 mm
 - Base Flow factor : $K_b=0.08\text{m}^3/\text{h}@1\text{bar } \Delta P$: $C_v = 0.09 \text{ GpM } @1\text{Psi } \Delta P$
 - Leads: 2 leadsx0.32mm² x80 cm
 - Operating Pressure Range 0-8 bar
 - Maximum Temp. : water 80°C , 180°F
 - Actuator Casing : Nylon
 - Seals : NBR
 - Wetted parts : stainless steel and polyamide
 - Base : Nylon (Optional: Brass)
- Electrical Data
 - power supply : 24V AC
 - Power : 1.7 Watt
 - Current (hold) : 0.25 A

Low Pressure Switch

- 1/4"F hydraulic connection made of galvanized steel
- standard protection degree IP44
- Max ambient cable clamps
- pressure range 0.1-0.9 bar
- The rest is automatic when the pressure becomes again than start value or when pressing then reset button
- Double electric contact: normally open ,made of brass alloy with Ag-Ni surfacing
- Terminals with M4 screws and 8x8mm pressure dice
- The deceive interrupts the electric connection between the line and the load when the pressure decreases below the established (Stop Pressure)
- Rated Current 16 A
- Rated voltage 250 V

High Pressure Switch

- pressure range 8-32
- Differential Pressure 1.8-6 bar
- Tightening torque max. 2Nm pressure gauge
- Pollution degree 3
- Short circuit protection ,fuse 16A
- Insulation 250 V
- Ambient Temperature -40 - 65°C

Anti-scalant System

Anti-scalant Dosing Pump

- Flow rate $Q = 0.2-0.8 \text{ L/h}$
- Working pressure = 2 bar
- Pump head PP
- Diaphragm PTFE
- Balls PYREX
- Fitting valve PP
- Seal/ O-Rings VITON
- Spring loaded injection valve Hastelloy/Pyrex
- Injection fitting PP
- Suction and bleed tube PVC
- Delivery tube PE
- Double scale pulse frequency selector 0-100 % and 0-20 % Analogue controls
- Constant flow rate adjustment via stroke frequency

Anti scalant Tank:

- Capacity : 250 L
- Medium : Anti-scalant Solution
- Material : PP

Level Sensor:

- connected to PLC
- Immersed in the Antiscalant tank
- Material Plastic

Disinfection System

Sodium Hypochlorite Dosing pump

- Flow rate $Q = 0.2-0.8 \text{ L/h}$
- Working pressure = 2 bar
- Pump head PP
- Diaphragm PTFE
- Balls PYREX
- Fitting valve PP
- Seal/ O-Rings VITON
- Spring loaded injection valve Hastelloy/Pyrex
- Injection fitting PP
- Suction and bleed tube PVC
- Delivery tube PE
- Double scale pulse frequency selector 0-100 % and 0-20 % Analogue controls
- Constant flow rate adjustment via stroke frequency

Sodium Hypochlorite Tank:

- Capacity : 250 L
- Medium : Sodium Hypochlorite
- Material : PP

Level Sensor:

- connected to PLC
- Immersed in the Sodium Hypochlorite tank
- Material Plastic.

Flow meter

- Meter body Cast Acrylic Rod
- Adapter Polypropylene
- Float S.S 316
- Guide Rod S.S 316
- Maximum working pressure 10.3 bar @ 21°C
- Maximum Fluid Temperature 65° @ 0 Psi
- scale 5 Gph
- Calibration fluid water

Electrical Panel:

RO enclosure 40x60x25 cm which includes:

- a. Main circuit breaker 3x25 A
- b. PLC with suitable circuit breaker with 30 % free space
- c. contactor and Overload for the primary pump
- d. contactor and Overload for the High pump
- e. Suitable LTL fuse breaker and RSTP Device
- f. Relay for the dosing Pump & Float Type Finder
- g. Circuit breaker for each dosing pump 1x2A
- h. Alarm, Start button and Restart button

PLC Specification

- ❖ Power Supply: 100~240 V AC (-15~10)% ,50/60 Hz \pm 5%
- ❖ Fuse 2A/250 V AC
- ❖ Power protection DC 24V output short circuit
- ❖ Insulation resistance > 5 M Ω at 500 V DC (Between all inputs/outputs and earth)
- ❖ Environment Operation : 0°C ~55 °C (temperature), 50~95% (humidity), Pollution degree 2
- ❖ Storage:-25°C ~ 70° (temperature), 5~95% (humidity)
- ❖ Input point type: Digital input
- ❖ Input type DC (SINK or Source)
- ❖ Input current 24 V DC 5mA
- ❖ Output point type Relay R
- ❖ Current specification 2A/1 point (5A/COM)
- ❖ Voltage specification Below 250V AC ,30V DC

PLC inputs:

- a. Permeate water level sensor signal
- b. Raw water tank level sensor signal
- c. Antiscalant tank level sensor signal
- d. Sodium Hypochlorite tank level sensor signal
- e. RSTP signal
- f. Start button
- g. Restart button
- h. primary pump Overload signal
- i. High pressure pump Overload signal
- j. High pressure switch signal
- k. low pressure switch signal

PLC Outputs:

- a. primary pump contactor
- b. High pressure pump contactor
- c. Dosing pumps Relay
- d. Alarm
- e. Electrical Valve

Water Storage Tanks

Raw water Tank:

- 2.0 m³ RAW water tank
- Coated with Supercryle 3 layers
- Mechanical float switch
- Electrical float switch connected to PLC controller.

Permeate water Tank:

- 2.0 m³ potable water tank
- S.S 316 with 2.0 mm thick.
- Electrical float switch connected to PLC controller.

Supplying all consumable materials:

- Supplying for the following consumable materials for three years from the project final handover :
 1. Anti-scalant
 2. Sodium Hypochlorite
 3. 20'' sediment filter

Stainless steel water dispensing unit

- Stainless steel water dispensing unit
- made of stainless steel sheets of grade 316
- 2.0 mm thick
- Supplied with six stainless steel 20 mm diameter taps.
- Carbon Filter placed inside a galvanized steel locker.

21 -WATER WELL

21.1 General

Drilling shall be performed by the percussion method, during which water and rock samples shall be taken according to the Engineers instructions. In addition, the Contractor shall be required to stop work for certain periods of time for the purpose of conducting interim tests, if required.

The Contractor has to complete all works included in this Contract and render the completed job not later than the date specified in the Contract.

The Contractor shall execute the work in accordance with the drawings and relevant British standards and code of practices.

21.2 Structure of Borehole and Work Proceedings:

(A) The drilling shall be executed in such a way as to permit the installation of a final permanent pipe not less than 12" in diameter. The Contractor is permitted to use 28", 26", 24" 22" and 20" auxiliary pipes.

(B) Each and every flight of auxiliary pipes shall be lowered only with the Engineer's approval and subject to any hydro geological alterations that may be encountered in the course of the Works.

(C) After reaching required depth, soil stratification shall be analysed and water-bearing Strata identified. Perforated pipe sections (screen pipe) shall be specified accordingly. Ordinary perforation shall be 0.5 - 2.0 mm wide (according to soil type) and 100 mm long. Vertical and longitudinal space between perforations shall be 50 mm.

(D) After installing the final permanent column of pipes a quartz gravel pack filter shall be placed in the space between auxiliary pipe and final permanent pipe. The gravel to be used is of the size 1.5-2.5 mm with not more than (5) % calcareous material by weight..

Under no circumstances will crushed rock or angular particles be utilized in gravel envelopes. The gravel-pack shall be carefully protected against contamination from dust, sand and foreign debris at all times. The contractor shall have available on site the exact grading size of gravel-pack. The uniformity coefficient of the gravel-pack shall be less than (2.0). Gravel-pack of rough and jointed surface will not be accepted. Before order and delivery, the contractor shall provide the engineer for his approval gradation curves of the gravel-packs, the source, location and country of origin and representative samples.

(E) The auxiliary casing pipes shall be extracted while placing the gravel pack filter. The Gravel shall be slowly placed from the bottom of the borehole to a depth as directed by the engineer and carefully controlled and packed.

Every precautionary measure must be taken during these operations to avoid any hazard of capitation.

(F) In case of sandy water bearing formation special perforation shall be installed to which gravel filter screens shall be fixed.

(G) Required size casing shall be retained permanently in the borehole and serve as protective casing against the upper sandy soil strata. This shall also enable the Contractor to place additional gravel to the gravel pack during test and well development pumping in case any settling of primary placed gravel is observed.

(H) Concreting of upper end of casing pipe shall be performed along with the extraction of the auxiliary pipes.

(I) Insertion of all pipes shall include cutting to the required size threading, connecting to one another by welding, and all work necessary.

(J) The Contractor shall transpose. And install seals and insert them between two columns of pipes

having different diameters the required depths and as requested by the Engineer.

(K) The Contractor shall provide a 4 mm steel plate and weld it to the bottom of the Permanent pipe.

(L) If soil characteristics prove that safe yield could be obtained from well without any gravel pack filter, respective changes in the detailed design for the completion of well shall be introduced by the Engineer and the Contractor shall duly abide new instructions.

(M) Centralisers shall be installed in each column of pipes inserted in order to allow them to be lowered in the centre of the well, at the same time allowing effective concreting, where necessary.

(N) The Contractor shall make a sanitary plug by insertion of cement in the annular space, from a depth of 15 m to 1 m. Other cementation works may be required at various depths in the annular space, and shall be performed at the request of the Owner, and according to his instructions.

The contractor shall keep a detailed record of drilling progress according to depth per hour, including a description of the layers and other phenomena encountered during drilling.

21.3 Verticality and Alignment Tests

The Engineer shall check the accuracy of the Contractors work execution from the point of well location, the diameters of the various sections, well verticality and alignment. For the purposes of the verticality and alignment tests, a gauge shall be used, composed of a steel pipe section with an external diameter 1" smaller than the internal diameter of the tested section, and 12m length. The test shall be performed by lowering the gauge into the well by means of a cable. The extent of deviation from the centre shall be measured by a 6m long gauge. The deviation from the vertical up to a depth of 100 m shall not be greater than 0.3% in one direction.

In the event that the Engineer has determined that the deviation exceeds the permissible value, he shall instruct the Contractor to cease work and correct the well, or abandon the well and drill a new well at a site nearby, at the Contractor's expense. In the event that the work is rejected as above, the Contractor must, within a period determined by the Engineer, carry out the corrections regulated in order to suit the well to the requirement of the specification and the required professional level, or drill a new well.

The Contractor, on his part, must conduct tests during the course of the work in order to ensure accuracy of drilling. Failure on the part of the Owner to conduct tests during the course of the work shall not detract from his right to demand corrections or reject the work up to completion of the well if it becomes clear to him that the work has not been properly carried out.

The tests described in this section, with the exception of the final measurement, should be regarded as standard and routine, and all expenses for their performance should be included by the Contractor in the unit prices quoted in the Bill of Quantities.

21.4 Rocks and Water Sampling

The Contractor shall supply boxes with rock samples taken from the various layers penetrated by the well. The Contractor shall have to supply at least two samples from each layer, one from the top and the other from the bottom of the layer, in addition to a sample at every two-meter depth of the well. The sampling, including the costs involved, shall be included by the Contractor in the unit prices for drilling quoted in the Bill of Quantities.

In the event that the Contractor fails to supply samples from the top or bottom of a particular layer, or fails to supply the number of samples required by the depth, and in the event that this causes damage or losses in any way to the Owner, the Contractor shall have to pay the contracted compensation, which shall be deducted from the amounts due to the Contractor according to the Contract the Engineer alone shall determine if any damage has been caused and the extent of the damage.

The contractor shall supply the Engineer with two complete sets of such sample, remuneration for which shall be included by the contractor in the prices of various works quoted in the Bill of

Quantities

Water samples shall be taken every meter below water level. Full analysis of water shall be performed to determine the different characteristics of water. The results shall be filled in the form attached hereto and should be approved by the Engineer.

21.5 Measurements of Water Levels

Full analysis of water results shall be filled:

During the period of drilling, the Contractor shall perform measurements to the depth of water level (hereinafter "the level") from the head of the pipe or from any other reference point in the well that shall be determined by the Engineer.

The measurements shall be performed in the event of any interruption in drilling, just before its resumption, or at any other frequency determined by the Engineer. The results of the measurements shall be entered in the work log.

The contractor shall supply to the drilling site an electric water level measuring instrument with electrodes and weights, or any other instrument suitable for this purpose.

The contractor shall be responsible for the proper working condition of the instrument, including supply of batteries, calibrated measuring cable and electrodes. The instrument shall remain at all times in the work area and shall be in working condition.

The type of instrument and its adaptation to performance of accurate water level measurements are subject to the approval of the Engineer. Supply of the instrument and auxiliary equipment, its maintenance, and performance of the measurements are considered to be routine activities and constitute an integral part of the drilling work. The costs of the Contractor in this regard shall be included in the prices of drilling.

21.6 Additional Tests

In addition to the above, the Engineer shall be entitled to give instructions for performance of various tests and to take samples of water from various depths and in various ways. Payment for the above shall be included in the price per meter.

Interruptions in drilling work caused as a result of the above tests, with the exception of the activities and tests defined and detailed above shall be considered as work stoppage.

21.7 Installation, Joining Of Casings and Screens

The casings and screens shall be installed in the open hole in one string by suspending from the surface. Under no circumstances shall they be driven or forced into the hole.

No casing or screens will be used for abandoned holes.

21.8 Pumping Test

The contractor shall perform development and test pumping in the well. The work includes installation of pumping equipment, and other works, in accordance with the requirements detailed below.

Performance /Test Pumping

Pumping shall be carried out with a vertical pump having a gear head and diesel motor suited to the requirements of the specification. The Contractor shall be requested to stop work for certain periods of time for performance of various tests or for technical consultations.

Description of Work

The contractor shall supply a source of power (diesel- motor) in proper working conditions, suited to the requirements as stated in this specification, with arrangements for obtaining different discharges. In addition, the Contractor shall supply all tools, accessories and materials necessary for performance

of the work, transport, install and assemble them, and perform the pumping, in accordance with requirements and the Engineers instructions.

The Contractor shall supply and install Pump outlet arrangements, included an inverted V-pipe, a calibrated water meter (with an official certificate of approval), a valve and an orifice for discharge measurements.

Appropriate pipes, attached to the pump columns, for allowing water level measurements using an electric cable. The meter reading at the commencement of pumping, on each change in discharge and at the end of each working day should be recorded in the pumping logbook.

For continuous pumping (day and night), the meter reading every 12 hours should be recorded in addition to the above.

Instructions for Performance of Test Pumping

Maximum discharge required: 20 cu .m/hr.

Maximum Depth of pump installation: 100 m

Pumped water shall be removed to a distance of about conditions in the area and Engineer's instructions.

Pumping

Pumping shall be perfumed by means of a pump as described in clause 8 (2) and shall commence with a low discharge, about 0.2 times the maximum discharge required according to the specification. Pumping shall continue at this rate, until clear, clean water and a stabilized dynamic water level are obtained, according to the Engineer's instructions in the field.

In this condition, the discharge may be increased to 0.4 times the maximum discharge required, with pumping continued until the conditions described above are obtained.

Pumping shall continue in stages, raising the discharge in each stage by about 0.2 of the maximum required value, until it reaches the required level. In the event that during the course of pumping, the water is still not sufficiently clean even though the water level has stabilized, pumping should be continued with interruptions according to the Engineer's instructions. Any modifications in the pumping program shall be made only after receiving instructions from me Engineer.

Pumping should only be commenced with a work docket, which shall include:

- Technical specification for performance of pumping.
- Technical cross-section of the well.
- Pumping logs.
- Reliable instruments in proper working condition for measurement of water level discharge and pressures.

Tests and measurements

The Contractor shall keep a detailed logbook in which the following details shall be entered

- Name of well, details of pumping equipment, drive mechanism, and date.
- Discharge- every hour and on change in discharge
- Water level-before commencement of pumping, during the course of pumping every hour and on change in discharge.
- Number of revolutions per minute of the pump-for continuous pumping and on change in discharge.

Water samples shall be taken at the Engineer's request. The Contractor shall record in the work log every detail and course of pumping.

The Contractor, on his part, shall conduct tests during performance of the work in order to ensure accuracy of pumping.

Pumping Regime

The Engineer shall determine, according to need, the pumping regime and whether pumping should be in the day and/or night. The price per pumping hour shall be uniform.

In the event that there is only day pumping, the Contractor shall be required to follow a pumping regime of 10 hours minimum pumping in winter and 12 hours in summer.

Additional Tests

The Engineer shall be entitled to give instructions for performance of various works. Payment for the above shall be on the basis of personnel hours. Interruptions caused as a result of the above additional works, with the exception of the activities and tests defined and detailed above, shall be considered work stoppages.

21.9 Cleaning Up

During its progress the work and adjacent areas affected thereby shall be kept cleaned up and all damage repaired so that the public and property owners will be inconvenienced as little as possible.

Where material or debris has washed or flowed into or been placed in existing watercourse, ditches, gutters, drains, pipes structures, work done under this contract, or elsewhere during the course of the contractor operations such materials or debris shall be entirely removed and satisfactorily disposed of during the progress of the work, and the ditches, drains, pipes, structures and work, etc..., shall, upon completion of the work, be left in a clean and neat condition.

The contractor shall restore or replace, when and as directed, any public or private property damaged by his work, equipment, or employees, to a condition at least equal to that existing immediately prior to the beginning of operations.

The contractor shall thoroughly clean all materials and equipment installed by him and his sub-contractors and on completion of the work shall deliver it undamaged and in fresh and new-appearing condition, all mechanical equipment shall be left fully charged with lubricant and ready for operation.

21.10 Permits, Licenses And Fees

Unless otherwise indicated in these contract documents, the contractor shall obtain and pay for all construction permits and licenses. Employer shall assist contractor, when necessary, in obtaining such permits and licenses. Contractor shall pay all governmental charges and inspection fees necessary for the prosecution of the work. Contractor shall also pay all charges of utility service companies of connections to the work.

22 – ELECTRICAL WORKS

22.1 GENERAL REQUIREMENT

22.1.1 Prerequisite Conditions

All applicable sections of the general Specifications are included by reference to the work required by this division of the specifications.

22.1.2 Extend of Work

The work shall include all necessary labour, materials, plant services machinery and appliances and alike at the Contractor's own risk and expense to deliver, construct, install and complete the electrical installation in good working condition in accordance with the drawings, specifications and bills of quantities. All materials and workmanship shall, except where otherwise directed, comply with the requirements and regulations of the appropriate local Electrical Authority, and I.E.E. and shall be subject to the approval of the Engineer.

Work shall also include:

- The procurement of and payment for all permits and licenses required for the performance of the work.
- All hoists, scaffolds, staging, runways and equipment required for the performance of the work.
- All job measurements and shop layouts required for the proper installation of material and equipment included in the work.
- All lights, guards and signs as required by safety regulations applicable to the work.
- The removal of all dirt and refused materials resulting from the performance of the work from the premises, as it accumulates,.
- All equipment under this heading shall be installed under complete supervisory service finished by the Contractor and where necessary, this shall include the services of special erection and operation engineers.

22.1.3 Miscellaneous Conditions

1. All installed material and equipment shall be new, with best quality and design, and free from defects and imperfections.
2. All the installation and adjustment of material and equipment shall be done by experienced electricians, has proper trade and all workmanship shall be first class.
3. Installed material and equipment included in the work shall be protected from dirt and damage and maintained in a clean condition during the performance of the work.
4. Apparatus, equipment and material required for the performance of the work shall be stored under requirements of applicable regulations and of direction from the Architect.
5. The Contractor shall cooperate with all other Contractors on the project, be responsible for prompt delivery of all materials and equipments and for the installation of all works under this division at a time and in a manner so that there will be no delay in the construction schedule.
6. Acceptance of the work shall be subject to the condition that all installed systems, equipment, apparatus and appliances included in the work shall operate and perform as designed and as selected with respect to efficiency capacity and quietness and shall operate and perform without producing objectionable noise within occupied area of the building.
7. Acceptance of the work shall be subject to the conditions that any time within one year after

date of final approval, any defective part of the work resulting from the supply of faulty workmanship or material shall be immediately amended, repaired or replaced as a part of the contract work without any cost to the owner.

22.1.4 Power Supply

The system of distribution will be fed from a 230/400 volts 3-phase, 4 wire 50 Hz.

22.1.5 System of Distribution

The system of distribution to be used for lighting and power is to be the radial type, including branch circuits and ring circuits system where shown in drawings.

22.1.6 Drawings and Specifications

All electrical drawings are intended to cover the layout and design of the work, but are not to be scaled for exact measurements. Where special detail and dimensions are not shown on the drawings, the Contractor shall take measurements and make electrical layouts as required for the proper installation of electrical work so that interference with all other work will be avoided.

All drawings and specifications on the project are complementary, each set to all other sets, and they shall be used in combination for the execution of the work. Electrical work shown on any set drawings, including all architectural drawings for general work and equipment, and electrical work called for under any section of the project specifications, shall be considered as included in the work unless specifically excluded by inclusion in some other part of the work. The work shall include roughing in for fixtures and equipment as called for or inferred. The Contractor shall check all drawings and specifications for the project and shall be responsible for the installation of all electrical work.

22.1.7 Inspection of the Site

Contractor shall inspect the Site, study existing conditions, check with the drawings and specification and be fully informed as to the work required by the Contract.

22.1.8 Operation and Maintenance Instructions

The Contractor shall furnish all services and personnel to the Owner's operating and maintenance as required for adequate verbal and written instructions. Two complete copies of a service manual in hard back binders shall be furnished at the end of the project and shall include printed operating and maintenance instructions for systems specified under this heading, all approved shop drawings and all manufacturers' printed instructions for operation and maintenance of the equipment.

When the work is completed and at a time designed by the Owner, the Contractor shall furnish the services of a qualified instructor to train the Owner's personnel in the operation and maintenance of the systems & equipment.

22.1.9 Record Drawings

Contractor shall be required to keep a day to day record of changes in location of all equipment, conduit, and devices on one or more sets of contract drawings, underground utilities or other readily identifiable feature.

The Contractor shall record such changes in red ink on black line prints. The record prints shall be submitted to the Engineer for approval prior to final payment.

22.1.10 Cutting and Patching

Any cutting of new construction which is required for the installation of electrical work after the construction of walls and floor slabs shall be done by the Contractor.

Cutting shall be done with extreme care so that the strength of the structure will not be endangered. Adequate protection shall be provided to prevent damage to adjacent areas. Patching and finishing of opening shall be the responsibility of the Contractor.

22.1.11 Existing Equipment

All existing equipment that indicated to be removed shall remain the property of the Owner if he so desires. Such equipment shall be removed by the Contractor and delivered to a point on the project site as designated by the Owner. Any equipment that the Owner does not desire to retain shall be promptly removed from the Site by the Contractor.

Any existing equipment or material that is to remain in service and is damaged by the Contractor during the course of the Contract shall be repaired and refinished or replaced to the satisfaction of the Owner, at his discretion.

22.1.12 Conduct of Work

All work under this Contract which may interfere with the operation of the Owner's utilities, shall be done in such a manner and at such time as may be satisfactory to the Owner. Make temporary alternations and connections as required to execute work so that all services in the building are maintained with the minimum possible interruption. Temporary shutdowns shall be segregated and shall be of the shortest possible duration. All services shall be kept on continuous operation unless permissions are otherwise granted by the Owner. All temporary wiring shall be the responsibility of the Contractor at no additional cost of the Owner.

22.1.13 Omissions

If anything necessary to the proper installation or operation of the electric system is omitted from the drawings or specifications, or bill of quantities, or indicated incorrectly, the Contractor shall call the attention of the Engineer to these omissions or inaccuracy immediately before work proceeds. Should the Contractor fail to do so, he shall be herder responsible and shall make good such errors or any damage caused at his own expense.

22.1.14 Samples

Samples of the following shall be submitted to Engineer by the Contractor before the work commences:

Section of conduit, section of wires and cables, junction boxes, switches and plates, outlet box isolating switches, lamp holders, ceiling roses ,distribution boxes, circuits breakers, earth leakage relays, any fixtures to be supplied by the Contractor and other materials to be incorporated in the installation. The work done by the Contractor shall not vary in any manner from the samples submitted and approved without written permission from the Engineer.

22.1.15 Layout

Before the Contractor commences the installation he shall discuss the exact timing and the whole layout in detail with the Engineer, in order to determinate the exact position of distribution boards, fittings and accessories, the runs of cable and conduits, etc.

22.1.16 Drawings

The design of the accompanied drawings and the quantities in the attached schedules are not definite and are subject to any variations made by the Engineer during constructions. No variations or amendments in the drawings and the specifications shall be instructed to the Contractor except as directed in writing by the Engineer who has the right to refuse all the materials and works which don't match with the drawings and specifications.

22.1.17 Testing

The Contractor shall make tests for perfect operation of installations, insulation and earth resistance and continuity at his own expense and in the presence of the Engineer

22.1.18 Tenderers

Tenderers for the electrical work shall have previous experience in this field of work and an official license of three-phase installations from the local Electrical Authority.

22.1.19 Risks insurance policy

The Contractor should provide on his own expense and all risks insurance policy for his workers during all the period of his work.

22.1.20 Director of works

The Contractor or his representatives should be on the Site daily for taking any instructions from the director of works (Engineer).

22.1.21 Owner reserves

The Owner reserves the right to accept any tender, either as regards the whole of the work indicated therein, or any one or, more parts so included. The Owner does not bind himself to accept the lowest of any tender.

22.2 MISCELLANEOUS WORK

22.2.1 Equipment Identification and Labels

All electrical equipments, such as disconnect switches, motor starters, controls, push buttons, panel boards, and other similar items shall be adequately identified with labels. Labels shall clearly designate name and use of equipment and be made of embossed plastic tape except where engraved plates are called for elsewhere in the specification or on the drawings.

22.2.2 Grounding

1. Grounding shall be in accordance with the local Electrical Authority requirements and regulations, and with the I.E.E. regulations.
2. All branch circuit conduit wiring shall include an insulated copper wire for grounding of all non-current carrying conductive surfaces of electrical equipment subject to person contact, and for every electrical outlet.

3. Earthing conductivity test should be conducted so that the resistance not exceeding 2 Ohm.
4. Earth electrode must be provided which consists of 3 driven copper rods 1,5 meter long of standard type, and must be installed as near as possible to the main board. The earth wire has to be copper conductor as specified making loop connection between the rods and the earth (ground) bus bar, the distance between each rod and the other have to be at least 7 meters with a checking manhole at least 60cm depth.
5. Other similar P.V.C. copper conductor has to be bonded to the main water supply pipe from the earth bus bar.

22.2.3 Adjusting, Aligning and Testing

1. All-electrical equipment furnished under this heading and all electrical equipment furnished by others shall be adjusted and tested by the Contractor.
2. Mechanism of all electrical equipment shall be checked for alignment with drive and adjusted as required. Protective devices and parts shall be checked and tested for specified and required application and adjusted as required. Adjustable parts of all lighting fixtures and electrical equipment shall be checked, tested and adjusted as required to produce the intended performance.
3. Complete wiring system shall be free from short circuits and after completion, the Contractor shall perform tests for insulation resistance in accordance with the requirements of the I.E.E.
4. The Contractor shall hold responsibility of the operation, service and maintenance of all new electrical equipment furnished by him during construction and prior to acceptance by the Owner. All electrical equipments shall be maintained in the best operating condition including proper lubrication. Operational failure caused by defective material and/or labour will be recovered by the contractor.

22.2.4 Motor and other Control Equipment

The Contractor shall install and mount miscellaneous disconnection switches and motor controls in accordance with the instructions, wiring diagrams and approved shop drawings, also he shall be responsible for the operation of such devices only to the extend of proper mounting and wiring. Work shall include mountings and supporting as required for all equipments including angle frames, steel plates, bars, bolts, etc. The Contractor shall furnish and install all conduit, wire, etc., as required to connect all equipment furnished by him including motors, disconnect switches, starters, controls, push buttons, etc.

The Contractor shall perform all work required to rough in and connect to all equipment required electrical connections, except equipment that is furnished by the Owner which shall be roughed in only. This work shall be as indicated on drawings, approved equipment shop drawings and by direction on the job.

The Contractor shall connect feeders to control and motors as shown on drawings, make connections and install wire to all mechanical components. The Contractor shall coordinate with other traders involved in the proper coil voltages for control of magnetic starters and contactors.

22.2.5 Opening and Setting of Conduit

Work shall include all required cutting and afterward patching for the installation of material and equipment included in the work.

Any cutting and/or patching of new construction which is required for the installation of Electrical work after new walls and floors have been constructed, shall be the responsibility of the Contractor if the cutting and patching is due to errors or omissions on the part of the Contractors.

22.2.6 Excavation and Backfilling

The Contractor shall excavate as required for the installation of all underground work under this heading. Surplus material not needed for backfilling shall be deposited or distributed in the premises as directed. Trenches shall be of sufficient width and shall be cribbed or braced to prevent cave-in or settlement. Trenches close to walls and columns shall not be excavated without prior consultation with the Engineer, otherwise it will be his representative. Pumping equipment shall be furnished to keep trenches free of water. Dry earth shall be rammed into place at the sides of conduits and leaving joints and top of conduits exposed until approved.

After approval, all trenches for work installed by the Contractor shall be backfilled by him in 15cm layers of well-tamped dry sand in a manner to prevent future settlement. Rocks debris, bricks, and like material shall not be used for backfilling. Where direct burial cable is installed, the trenches shall have 5cm of dry sand on the bottom of trench.

Any trenches improperly backfilled or where settlement occurs, they shall be reopened to a depth required for the proper compaction, then refilled and compacted with the surface restored to the required grade.

As a part of this Contract, all roads, streets, and sidewalks damaged by the installation of building services or other work under this heading shall be furnished to the satisfaction of the authorities and regulations having jurisdiction.

22.3 GENERAL CONDITION OF THE DIFFERENT PARTS OF INSTALLATIONS

22.3.1 CONDUITS

1. Conduit shall be installed for all wires and cables except where otherwise stated or directed. The conduits shall be P.V.C. pipe of the thinner type or similar under plaster.
2. Fireproof plastic type should be used whenever exposed installations are used. In addition, conduits shall be securely fastened in place with approved straps.
3. Steel conduit should be used in the boiler, and where else directed by the Engineer.
4. No conduits should have an internal diameter less than 13mm. The Conductors area within the conduit should not exceed 50% of the area of the conduit.
5. The conduit has to be away from heat and mechanical pressure.
6. The contractor shall be responsible for ensuring that the conduits are laid so that water cannot infiltrate or accumulate at any point.
7. The Contractor shall be responsible to ensure that placing of the conduit is done prior to pouring of concrete without delaying the concrete work.
8. The Contractor should make all his effort to run all the conduit pipes in horizontal or vertical lines and not to be inclined and to be at the same level from the floor in all rooms.
9. The conduits should have cover at least of 2cm of plaster or concrete.
10. Separate conduits have to be used for separate systems of different voltage.

11. Conduits between any two connection boxes have to be of one piece with no connection in the pipes.
12. Where finish wall surfaces are to be plastered, the Electrical Contractor shall cooperate with the General Contractor during construction of these walls and use care in the installation of all conduits and boxes so that wall surfaces will have a finished appearance
13. Conduit shall be installed to requirements of structure and to requirements of all other work on the project. Conduits shall be installed so that to divert from all openings, depressions, pipes, ducts, reinforcing steel, etc., and conduits set in the forms of concrete structure shall be installed in a manner that installation will not affect the strength of the structure.
14. All electrical work shall be protected against damages during construction and any work damaged or moved out of line after roughing-in shall be repaired and re-set to the approval of the Engineer, without additional cost to the owner.
15. All conduits have to match the local standard.

22.3.2 PULL BOXES AND CONNECTION BOXES

1. The contractor has to make his best to use the minimum number of these boxes.
2. All boxes should be of the same material as that of the conduits.
3. Boxes should be wide enough to contain all connections of cables easily.
4. Pull boxes and connection boxes should be installed all at the same level from ceiling.
5. All boxes should be covered.
6. All the connections for installed connectors should be done inside the boxes.
7. Cables of different voltage should not be drawn or connected in the same connection box.

22.3.3 OUTLET BOXES

1. Suitable outlet boxes shall be installed for all electrical service outlets, including plug receptacles, lighting fixtures, switches, etc.
2. Location of outlets on drawings is approximate and except where dimensions are shown, exact location of outlets shall be taken from plans and details on general drawings or as directed by the Engineer.
3. Outlets shall be located generally from column centers and finished wall lines or to center of acoustical and decorative ceiling panels and to centers or joints of wall panels.
4. Outlets shall be installed in an accessible location.

22.3.4 SWITCHES

1. Outlet boxes for switches are to be fixed 140cm above finished floor level and 12cm horizontally from the outside edge of the nearest door.
2. Switches should be of 10 amp with different signs for emergency switches if used.
3. Switches should be of waterproof type for the bathrooms and where else shown.
4. All switches should be installed flush.
5. Switches shall be wired in the phase lines only.
6. The neutral conductors shall not be broken.
7. Switches panels shall have a similar assembly to switches and should be group-mounted in a common box if possible, and if it is without pilot lamp, otherwise it has to be group-mounted in aluminum or stainless steel cover to the approval of the Engineer.

22.3.5 SOCKETS

1. Boxes for sockets outlets are to be installed 60cm or, as shown in the drawings above finished floor level.

2. Socket should be of 13 amp or 16 amp for the power socket with different color for socket and non-emergency.
3. Sockets should be of all-installed rockers flush.
4. Sockets in the boiler room should be industrial heavy duty.
5. Sockets in the bathrooms and where else shown shall be waterproof.
6. All sockets shall be wired in the same manner with the phase always connected to the same pole [right pole].

22.3.6 WIRES, WIRING

1. All wires and cables, except where otherwise stated are to have a soft copper core, refined and tinned, with an electric conductivity of not less than 98%. The core shall be insulated with rubber with braid for 600 volley service.
2. Samples of cabling and wiring proposed by the contractor, are to be submitted prior to commencement of the work. These must comply with the requirements of the I.E.E., and local standard to ensure a constant voltage in every part of the building.
3. All wires are to be standard. [for lighting and power, the neutral wire shall be different in color from the phase wires].
4. All wires shall be run through conduits and shall be continuous between outlets and boxes. At least 20cm of wire to be left outside the outlet for fixture connection.
5. Where wire size is shown on drawings or specified, it shall be the same size throughout the circuit.
6. Wiring inside panel boards shall be neat and well arranged, using appropriate lugs for termination and connection of conductors.
7. Joints in the cables or wires are not allowed to be made inside conduits.
8. Wires are to be fixed to boards with an appliance ensuring perfect electrical contact, to the approval of the Engineer.
9. When drawing wires through conduits, no lubricant is permitted.
10. Cable shoes have to be used for wires of 6 sq. mm. or above.
11. All boxes and distribution boards have to be carefully cleaned from plaster and other foreign material before drawing any electrical wires or cables.
12. Colours of the cables should be as follows:
 - Single phase circuits:

Brown	for the phase
Black	for the neutral
Green & Yellow or White	for the earth
Blue	for direct [switch Wires].
 - 3 Phase circuits:

Brown, Yellow & Blue	for the three phase.
Black	for the neutral
Green & Yellow or white	for the earth

22.3.7 Cables

1. All the cables should be of the following type NYY, 5 or 4 cores, 11000 volt, plain annealed high conductivity copper wire conductors P.V.C. sheathed. Under Ground cables should be of type NYBY or XLPE.
2. Colours of cores in the cable should be red, yellow, blue & black. Colours of sheathes shall be black.
3. Cables terminations should be through brass cable glands. Glands should be complete with brass earth tags and steel locknuts.
4. Cable connection at both ends should be through cable shoes.
5. Cables should be covered with soft sand, concrete slabs and special warning tape in 3

languages.

22.3.8 Wire Size

1. Sizes of wires should be 1.5mm² for lighting and 2.5mm² for socket outlets and local ring main circuit unless otherwise indicated in the contract documents or instructed by the engineer.
2. The size of the earth cable for any circuit should be the same size as that of the phase or as shown on the drawings.
3. The size of the wire for the bells, loud speakers and sound outlets should not be less than 0.6sq.mm

22.3.9 Electrical Boards

1. All boards should be manufactured by a qualified factory who has a wide experience in this field.
2. The Contractor should supply detailed drawings for each board which show the electrical and mechanical design of the board with dimensions. Therefore, the contractor shall get the approval of the Engineer before he commences with the manufacturing of these boards.
3. Electrical boards should be erected complete with all conduits terminated to it before installation of any cable in the conduit.

Body of Electrical Boards

1. Electrical boards and panels shall be ready made otherwise it should be manufactured from 2mm galvanized steel sheet with all angles and channels needed for supporting and mounting the equipments and it should be full finished steel with electrostatic painting with beige colour.
2. All screws, nuts and washers should be galvanized.
3. Boards to be designed with removable front plates for easy access to the interior for cabling up and maintenance.
4. A special compartment with separate cover shall be made for terminals, neutral and earth bars.
5. All panel boards shall be with doors.
6. All doors which have equipments mounted on them shall be shielded from inside with isolation sheets.
7. Distribution Boards in wet areas should be of waterproof type.
8. All electrical boards shall have spare space of at least 25% of their space.

22.3.10 Bus - Bars

1. All bus-bars shall be of hard drawn electrolytic copper.
2. Bus bars shall be supported by suitable bus-bar insulator to protect the bars from any electrical, mechanical and dynamic stresses.
3. Bus-bars shall be rated at a max. of 2 amps/sq. mm.

22.3.11 Neutral and Earth Bars

Suitable bars for neutral and earth shall be mounted on the top compartment of each board, for terminating the outgoing circuits on them. A bolt with suitable size shall be welded on the body of each board for earthing.

22.3.12 Labels

All circuits shall be labeled in English language and to be of the black sandwich type and engraved.

22.3.13 Main C.B.S

These C.Bs shall be air insulated, adjustable, with magnetic and thermal protection, and have a main

rupturing capacity of 25 K.A.

These C.Bs shall be of the best quality and preferably of the Siemens or NZM-type K.L.M made. in Germany or equivalent.

22.3.14 Miniature C.BS, Automatic Change Over Switch, [Mechanical Interlock] and E.L.Rs.

The M.C.Bs shall be of the air insulated type with magnetic and thermal protection and fixed adjustment, the main rupturing capacity of these M.C.Bs shall not be less than 15 K.A. The M.C.Bs type N and E.L.R. shall be of the best quality and preferably Siemens or NZM-type K.L.M made. in Germany or equivalent. All E.L.R. shall be 4-pole with 0.03 amp sensitivity.

22.3.15 On - OFF Switches

All these switches shall be hand operated, air insulated and able to withstand any load and fault conditions.

These switches shall be Siemens type or K.L.M. made or equivalent.

22.3.16 Instruments

All the measuring instruments shall be very accurate which have dimensions of 120x100 mm. and mounted on the boards.

All ampere and volt meters shall be with selector switches to measure the voltage between phases and between phases and the neutral.

22.3.17 Connectors

All outgoing connectors shall be terminated and mounted on the upper compartment of the boards or otherwise shown in the drawings.

Connectors must have a copper strip between the wire and the screws. All connectors shall have special paper fixed on them for writing the names of the circuits. Connectors shall be of or best quality.

22.3.18 Telephones

1. 1" conduit should be installed from each telephone box to the main telephone box in the floor where shown in drawings with galvanized rope to be installed within for the telephone company.
2. The telephone box should be 1 meter high from floor level unless otherwise indicated.
3. Main conduits from the floor boxes and the operator have to be shown in drawings with a galvanized rope.
4. Telephone cables for the main boxes and the telephone outlet should be drawn with the presence of the telephone department.

22.3.19 Fire Alarm Installations

1. MICC/PVC sheathed cable only shall be used for the wiring of the fire alarm, smoke detectors, etc., associated with the installation.
2. Where interconnections are to be made between buildings for control panel displays, PVC/SWA/PVC cables may be used.
3. Size of wire for Fire Alarm should be at least 1.5 sq. mm.
4. Fire alarm system shall include the following:

- Smoke detectors
- Heat detectors
- Addressable break glass call point
- Short circuit isolators
- End of line resistors
- 6" diameter ,24V internal fire bells (sounder)
- Addressable repeater FACP (X-zone)
- Voice evacuation and emergency telephone system (auto dialer)

5. The FACP shall indicate :

- Zone leds main fire
- Fault and pre-alarm leds
- Power tests, system fault, alarm fault, remote signal and activated sound and silence alarm leds
- The duration of the FACP will be 24 hours standby

22.3.20 Lightning System

- 1- Lightning system should be implemented in compliance to drawings and American Standard NFPA78.
- 2- The Contractor has to submit samples of the lightning system components to the Engineer for approval.
- 3- Electrodes and strips should be made of copper type 11000C according to ASTM-B187 or equivalent.
- 4- After installation of the lightning system to be completed, the contractor has to make earth leakage and resistance tests for the system according to the American Standard and under supervision of the Engineer.

22.3.21 Lighting Fixtures Schedule

Type of lamp	Description	Manufacturer
A	2X20 W, of 4000 lumen with concaved aluminum louvre ceiling or wall	Philips or equivalent LED 2x20 W
B	1X16 W, of 1600 lumen with asymmetric reflector ceiling or wall	Philips or equivalent LED 1x16 W
C	2X20 W, of 4000 lumen ceiling or wall	Philips or equivalent LED 2x20 W
D	1X20 W, of 2000 lumen ceiling or wall	Philips or equivalent LED 1x20 W
E	IP-64, 60watt low bay LED of aluminum alloy body, 5400 lumen	Philips or equivalent LED 60 W
F	Surface mounted globe with polycarbonate cover and 2X10 W LED lamp	Philips or equivalent LED 2X10 W
G	IP-65, globe with polycarbonate cover and 15W LED lamp	Philips or equivalent LED 15 W
H	IP-54 cast aluminum body, metal protection with sealing gasket and 15W LED lamp.	Philips or equivalent LED 15 W
I	IP-66, 2x20w with 4000 lumen, surface mounted on ceiling, with reinforced polycarbonate cover and concaved aluminum optic.	Philips or equivalent LED 2X10 W
J	IP-66 flood led light fitting of 12000 lumen and 104W power.	Philips or equivalent LED 104 W

22.4 Photo-voltaic energy system

22.4.1 Brief Description of the System

The photovoltaic system is essentially composed by:

- Main device of connection with the utility
- Decoupling protection and decoupling device
- Generator Device
- Conversion inverter DC / AC
- Decoupling Device Switch board
- Photovoltaic panels
- Support Structures and anchor
- Island Inverters AC/DC
- Storage lead batteries
- Multicluster box
- Cables
- Cable trays and ducts

The works shall include professional erection of solar energy modules, D.C protection junction boxes, inverters, D.C batteries, charging controllers, metallic works, wiring and cabling, interconnection to mains supply and monitoring system.

The scope of work shall include also the testing and commissioning, technical documentation and supplying operation and maintenance manuals in both Arabic and English languages.

All works shall be carried-out in a manner satisfactory to the supervisor engineer and all unspecified materials shall be of approved manufacture. The complete installation is to be to the entire satisfaction of the supervisor engineer, as well the contractor has to supply all labor, materials, equipment and tools necessary for supplying and installing the project's works.

22.4.2 Specialist Contractors

The photo-voltaic solar energy system shall be implemented by an approved Specialist Contractor who has a satisfactory experience in field of supplying, installation, operation and maintenance of this innovative technology.

The summary of this work shall include but not limited to:-

- a. Preliminary works such as piping, conduits, marshalling boxes, cutting and forming of holes for conduits or pipes through walls and making good after the work is sufficiently advanced.
- b. Metallic works which consists of photo-voltaic modules/panels' aluminum anchoring structure, profiles composed of extruded aluminum, rivets with seal of an aluminum body and shank and a neoprene rubber seal.
- c. Galvanized steel cable tray work which includes G.S perforated trays, G.S brackets, rivets, elbows, supports and all needed accessories for arrangement.
- d. Installation of photo-voltaic solar energy modules/panels in proper manner which should be taken into account the most suitable orientation and tilting of these modules/panels to get the maximum amount of solar energy which in turns provide the maximum amount of electric energy.
- e. Installation D.C protection boxes which shall include D.C breakers, D.C fuses, connection terminals, connection wiring and glands.
- f. Laying and connecting solar energy wiring between photo-voltaic modules/panels and D.C protection boxes.

- g. Installation the D.C batteries in proper manner including metallic racks which should be of bearing capacity higher than the gross weight of all batteries to be arranged on.
- h. Interconnecting the D.C protection boxes to the inverters including charger controllers' installation, D.C combiner box of the batteries and monitoring & controlling system.
- i. Testing and commissioning the overall system including filling readings record and calibration of modules/panels and equipment to get optimum situation.

22.4.3 Witnessing Of Procedures

The testing and commissioning procedures will be witnessed and arranged by the supervisor engineer.

22.4.4 Materials

All materials shall be as shown on the relevant drawings. The tender shall be based on the materials as specified. All materials shall comply with standards stipulated this specification. The supervisor engineer reserves the right to inspect materials on site or in factory at reasonable times and to reject any materials not complying with the specifications.

22.4.5 Name plates

The project's equipment supplied under this contract shall, where appropriate bear nameplates giving makers name, date of manufacture, size and type together with all particulars which aid identification for the future ordering of spare parts

22.4.6 SOLAR ENERGY SYSTEM COMPONENTS

22.4.6.1 Preface

It is understood and agreed that the Contractor has, by careful examination of the drawings and specifications and the site where appropriate, satisfied himself as to the nature and location of the work and all conditions which must be met in order to carry out the work under this section of the contract.

The scope of the work consists of furnishing and installing of the complete photo-voltaic solar energy system for the targeted installation with all preparations and arrangements needed.

The contractor shall provide technical staff, labor, materials, equipment, machinery, and all other items necessary to complete the system.

The contractor shall be responsible for the detailed design, manufacture, supply, transport, and installation at site, testing, commissioning, proper operation and safe functioning of the electrical components.

If the contractor stipulates otherwise or proposes other current and/or power ratings for photo-voltaic modules/panels, inverters, charger controllers etc. the electrical installations (circuit breakers, fuses, contactors, wiring, cables etc.) shall be adjusted to fit the new modifications in the system without any financial compensation.

22.4.6.2 Power flow

The power flows have been considered from the point of view of green energy.

The energy is commonly generated by the photovoltaic system and used by the loads.

The photovoltaic system works in parallel with the grid and during this phase the batteries are kept in float charging throughout all their standby period; if the power produced is bigger than that one absorbed by the loads the Sunny Island Inverters produce a phase displacement introducing a power factor changing the frequency and reducing the active power, producing reactive power: there will be never energy sent into the grid.

If the power produced is lower than that one requested a part of energy is provided by the grid.

When the grid is off the power is totally produced by the panels. If the power requested by the loads is bigger than the one produced the batteries start to discharge themselves until a level set up by the user (usually not more than 30/40% for increasing the batteries life).

In case of over discharging the system will go off and wait for power back to start producing power charging the batteries and supplying the loads.

22.4.6.3 Inverters

The system can work as an island grid that is an electricity network independent by the public utility network. It provides a stable energy supply by managing all processes.

A network for Sunny Island is arranged as AC three-phase and includes one type of electricity generator which is PV systems and the batteries for energy storage.

Tripower grid inverter:-

The DC power produced by the photovoltaic panels is converted into AC power through three inverters Tripower SMA STP15000TL-10 +RS485 type set off grid.

High Yields

- Maximum efficiency of 98.2 %
- Best tracking efficiency with OptiTrac MPP tracking
- Bluetooth communication

Safe

- Triple protection with Optiprotect:
- Electronic string fuse
- Self-learning string failure detection
- DC surge arrester (Type II) can be integrated

Flexible

- DC input voltage up to 1000 V
- Integrated grid management functions
- Custom plant design with Optiflex

Simple

- Three-phase feed-in
- Cable connection without tools
- SUNCLIX DC plug-in SMA Sunny Tripower 12000TL system
- Easily accessible connection area

Master and slave cluster inverters:-

The central component of the stand-alone grid is the battery inverter, the Sunny Island.

In its role as grid former and manager, it maintains the stability of the AC network and ensures that voltage and frequency remain within permissible limits. The Sunny Island is a bidirectional battery inverter and is often referred to as a combined inverter/battery charger.

It takes care of storing excess energy in the battery and supplying the grid with power from the battery. These devices are particularly cost-effective because they perform both functions via the same power semi-conductors.

The Sunny Island is equipped with both grid management and with a highly developed battery management function, which includes monitoring. Thus it is continuously updated on the exact battery charge and as system manager makes necessary ongoing decisions.

When the batteries are empty and there is little generation capacity, it activates the diesel generator or even switch off certain consumer loads. It also determines the optimum strategy for charging the batteries, and in so doing, increases their lifespan.

Furthermore, this compact device provides additional functions specifically geared for the requirements of stand-alone networks.

Automatic reactive power compensation with a possible phase shift of -90 degrees to $+90$ degrees (shift factor from 0 to 1 inductive/capacitive), the Sunny Island can, if necessary, convert its entire nominal power to reactive power. Thus, it is capable of compensating phase shifts in the stand-alone network brought about by inductive or capacitive loads (e.g., engines, transformers, cable lines).

Additionally, a conventional backup generator is connected to keep the system supplied with energy under all circumstances.

Three by-directional inverter SMA SI6.0H-11 type shall be provided as master.

The master is the control center and communication within a cluster and performs the following activities:

- Activation and deactivation of slaves
- Control and management of slaves, for example, adjustment of frequency and voltage
- Control of the charge and discharge of the battery
- Control of capacity and charge level of the battery
- Saving data in the cluster and the battery on the MMC
- Request the diesel generator
- Data exchange with the masters of other clusters
- Carrying out the two slave firmware update
- Display of the values and states of the system
- Registration at the central level of the data entered by users

Six by-directional inverter SMA SI6.0H-11 type shall be provided as slaves.

A slave is a functional unit subordinate to the master. A slave receives its settings configuration, the current firmware as well as the start and stop commands from their master. Submit their operational data to the master and executes the commands.

OptiBat - battery management

- Automatic control of the most important charge and discharge processes
- Longer service life for sensitive energy storage

OptiUse - easy to operate

- Quick installation and commissioning
- Easy operation
- Automatic, rotating, magnetic field detection
- Optimized quick configuration guide

OptiPower - load and energy management

- Secure operation in any situation
- Generator support
- Soft start

22.4.6.4 Multi-cluster box with NA Box

The core element of Multi-cluster technology is the Multi-cluster Box which is available in three power classes. As a pre-configured AC distribution, it enables easy connection of all AC components in the stand-alone network, including generator and photovoltaic plants loads and the three clusters, each made up of three Sunny Island inverters.

There are connections for each Sunny Island inverter, main connections for the generator, and for the photovoltaic generating plant and loads.

A power contactor is integrated into the Multi-cluster Box for both load and generator connections.

The generator contactor connects the diesel generating set if available.

In contrast to generators in grid-parallel operation, they cannot synchronize with an existing grid, and therefore in this case, the generator specifies the grid parameters. The cluster group of Sunny Island inverters adjusts accordingly, meaning the connection is established as soon as voltage and frequency with the pre- and post-generator contactor are synchronized.

If the Sunny Island cluster fails or is switched off, the generator contact closes automatically directly linking the generator to the connected loads. On the other hand, in the event of a generator failure, the system immediately disconnects and maintains supply with battery power and the available renewable- energy generators. Thus, secure operation is assured even when one component fails.

If the generator stops working for an extended period and the regenerative sources do not provide sufficient energy to fully supply the loads, the energy stored in the battery will be used. When a lower discharge threshold is reached, the contactor on the load side opens and disconnects the line.

This prevents deep discharge of the battery and switching-off the cluster.

On the other hand, to avoid unnecessary load peaks, load management is managed by the Sunny Island inverter multi-function relay. Each device of the main cluster has two relays available, to which it is possible to assign one of 17 functions using the device menu.

In addition starting the generator when battery charge is low, it is also possible to connect individual loads via a separately installed contactor.

In the event of grid failure, the NA Box always disconnects the multicluster system from the utility grid at all poles, when the NA Box is used in accordance with the VDE-AR-N 4105, it must be ensured that the multicluster system never feeds more than 100 kW into the utility grid.

Functions of the Multi-cluster Box:

- Load shedding
- Automatic bypass for the generator
- Active anti-islanding
- Reverse current monitoring

22.4.6.5 SMA Cluster Controller

The SMA Cluster Controller is the system interface for power supply companies, direct marketers, service technicians and PV system operators.

It will be combined with highly efficient SMA inverters, the SMA Cluster Controller is the central communication unit for system monitoring, recording data and controlling large-scale PV plants.

Through a variety of analog and digital in- and outputs as well as fast data exchange via an Ethernet-based data interface (e.g., Modbus TCP), a wide range of applications can be realized, from feed-in management to sensor technology integration, in addition there are infinite options for visualizing yields via the Sunny Portal connection.

22.4.6.6 Sunny Remote Control

Sunny Remote Control is to commission and monitor the battery-powered inverters conveniently without having to be standing right in front of the inverter. The Sunny Remote Control should be used at a distance of up to 20 m and processes information from up to three devices.

It is equipped with rotary switch enables intuitive operation. The four-line display gives you information on the current plant status at a glance. An SD card serves as the service interface.

22.4.6.7 SMA Energy Meter

The SMA Energy Meter takes phase-accurate and balanced electrical measured values, such as a grid feed-in and purchased electricity meter, and communicates these values via Speed wire.

This in turn, facilitates optimal energy monitoring, effective load and battery management and reliable active power limitation at the grid feed-in point while taking self-consumption into account.

22.4.6.8 Solar DC battery

Lead Acid Batteries **Fiamm** OPzV technology will be provided.

The tubular positive plates and electrolyte immobilized in gel have been dimensioned according to DIN **40742 OPzV** cells.

Suitable for use at elevated temperature have been optimized for deep discharge recovery DIN 43539T5.

18 year design life under float condition.

Minimal gassing and maintenance free (no topping-up)

Completely Recyclable

Other characteristics are:

Tubular positive plates, pressure cast from high tin / low calcium alloy

- Electrolyte immobilized in gel structure
- Highly porous gauntlets retain the active material
- Pasted negative plates designed to have service lives consistent with the positive plates
- Separators with extremely high porosity and low internal resistance
- Standard ABS plastics (Optional flame retardant plastics ABS IEC 707 FV0 and UL 94 V0 with LOI greater than 28%)
- Container and lid designed for unsurpassed mechanical strength made of thick walled plastics
- Threaded female M10 terminal posts guarantee highest conductivity, maximum torque retention and easy installation
- High integrity post seal design to prevent electrolyte leakage and terminal corrosion
- Flame arrestors prevent sparks or flames from entering the cell
- Cells equipped with one-way safety valves to allow excess gas to escape when overcharging
- - < 2% self-discharge per month at 20°C allows 6 months shelf life
- Installation in vertical or horizontal position
- Flexible, fully insulated cable connectors with insulated screw with probe hole on the top for voltage measurement
- **Solar 2V cells 2600 Ah real capacity at C120 1.85 VPC**
- Designed for regular and long deep discharge Ideal for: Solar energy islands Excellent cycling also in state of partial discharge

> 1.500 cycles at 20°C / 60% DoD

> 5.000 cycles at 20°C / 20% DoD

The battery capacity is rated in ampere hours (Ah) and is the quantity of electricity which it can supply during discharge. The capacity depends on the quantity of the active materials contained in the battery (thus on dimensions and weight) as well as the discharge rate and temperature.

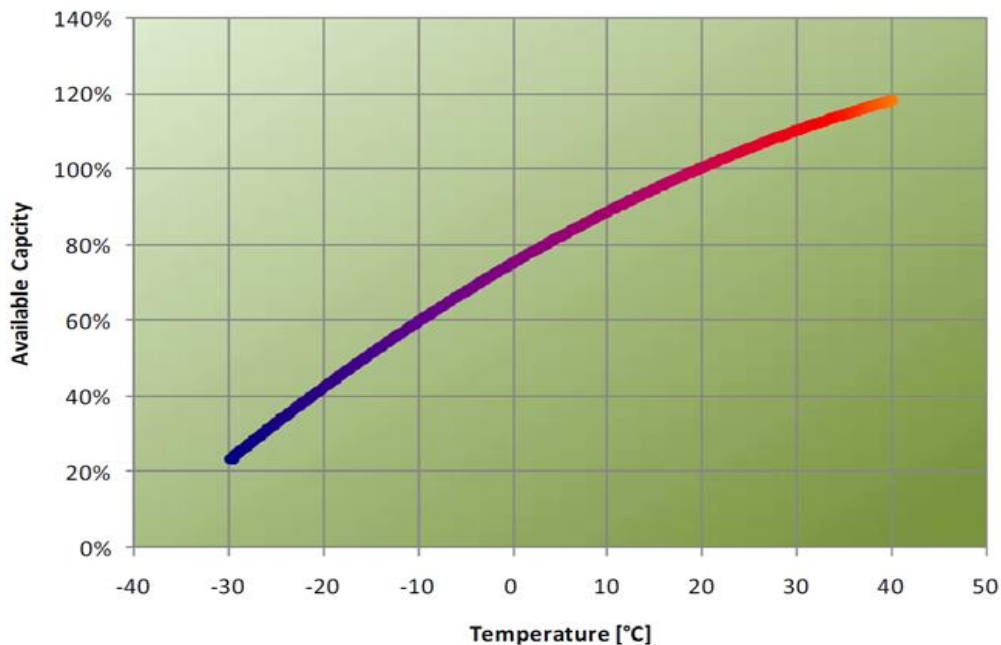
The nominal capacity of FIAMM Solar batteries refers to the 120 hours discharge rate (indicated with C120) with constant current at 20°C to 1.85 volt per cell as per CEI EN 61427.

The capacity available from a battery, at any particular discharge rate, varies with temperature.

Batteries which have to operate at temperatures different from the nominal (20°C) need an higher/lower capacity as per the factor indicated in the following graph (required capacity has to be multiply by the correction factor stated in the graph).

▪ Required certificates:-

• DIN 40736-1, IEC 60896-11, EN 50272-2 and ISO 9001:2000.



22.4.6.9 Photo-Voltaic Solar Module/Panel

Photo-Voltaic solar module shall be robust with not less than 72 solar cells. These modules can be used for on-grid and off grid solar applications. The design and production techniques shall ensure a high-yield, long-term performance for every module.

Quality Certificates:-

- IEC 61215 / IEC 61730, UL 1703, CEC Listed, CE, MCS.
- ISO9001: 2008: Standards for quality management systems.
- ISO/TS16949:2009: The automotive quality management system.

Environmental Certificates:-

- ISO14001:2004: Standards for Environmental management systems.
- QC080000 HSPM: The Certification for Hazardous Substances Regulations.

- Reach Compliance. Copper connectors with cross

22.4.6.10 Photovoltaic system electrical distribution

The components of electrical distribution will be provided as follows:

- Electrical switch boards
- Decoupling device and protection
- Generator device
- Surge protection device
- Cables
- Cable trays

The electrical distribution connects the following devices:

- The main switch board to the secondary switch boards and to the decoupling switch board
- The decoupling switch board to the multicluster boxes and to the AC/DC string inverters
- The multicluster boxes to the island inverters, to the loads and to the decoupling switch board
- The island inverters to the batteries
- The photovoltaic string to the AC/DC string inverters

It runs in ducts inside the building till the main switch board and in cable trays on the cover.

- **Electrical switch boards**

The main LV switch board will incorporate power factor correction equipment to achieve a power factor of 0.95 or better.

- Rated voltage 660 V
- Rated operational voltage $400 \pm 10\%$ V
- Impulse withstand peak voltage 6000 V
- Conditions of installation Indoors.
- Service conditions ambient air temperature and altitude as EN 60439

- **Generally**

- Switchgear: Factory built
- Free standing switchgear: Provide lifting bolts within reinforced top frame
- Neutral terminations: Match current carrying capacity of phase conductor
- Insect proofing: Cover assembly openings with non-combustible and non-corroding insect proof mesh.

- **Distribution Boards**

- Standard: To EN 60439-1.
- Distribution board and type tests: Fully type tested.
- Enclosure:
 - Ingress protection to EN 60529: IP44.
 - Material: Metal.
 - Finish: Powder coated.

- Colour: Manufacturer's standard.
 - Locking mechanism: Cylinder locks with a standard key type.
 - Incoming device:
 - Type: Switch-disconnector.
 - Poles: 3/4.
 - Busbars and connections: Fully shrouded.
 - Position within enclosure: Locate in same position relative to protective device for each pole.
 - Neutral and earth bars: Individual terminal for each outgoing circuit.
 - Outgoing devices Circuit breakers.
 - Spare current carrying capacity (minimum): 20%.
 - Spare ways: Fit with blank plates.
 - Identification:
 - Neutral and earth bar terminals: Label with the outgoing circuit reference.
 - Cable terminations: Label with circuit reference, with push-on plastics markers.
 - Accessories:
 - Current transformers;
 - Digital multi-function metering equipment;
 - Indicator lamps; and
 - Padlocks and keys
 - As Circuit schedules.
- Air circuit breakers
- Standard: To EN 60947-2.
 - Door interlocks: Prevent enclosure doors being opened while circuit breakers are closed.
 - Properties:
 - Utilization category: A.
 - Interrupting medium: Air.
 - With RCD: Yes.

Residual Current Circuit Breakers

- Standard: To EN 61008-1.
- Properties:
 - Rating: As Circuit schedules.
 - Poles: As Circuit schedules.
 - Sensitivity: As Circuit schedules.
 - Time delay: As Circuit schedules.

Switches, Disconnectors, Switch-Disconnectors And Fuse

- Standard: To EN 60947-3.
- Properties:
 - Terminals: Suitable for the connection of copper conductors.

Residual Current Circuit Breakers With Integral Overcurrent Protection

- Standard: To EN 61009-1.

Busbars

- Standard: To EN 13601.
- Approval: ASTA certified.
- Material: Hard drawn high conductivity copper.
- Cross section: Rectangular with radiused edges.
- Enclosure:
 - Ingress protection to EN 60529:.
 - Finish: Powder coated

- **Parallel string box**

In order to connect the photovoltaic strings to the inverters parallel string boxes will be provided with the following features:

Housing

- Polycarbonate grey

Cover

- Polycarbonate transparent

Bracket

- Stainless steel AISI304

Rated Voltage

- 800 V

Isolation

- Class II

Max incoming Current

- 100 A

Enclosure degree of protection

- IP65

- **Control and monitoring**

A SMA **Webbox** will be provided.

It receives and stores current measured values and transmits data via RS485.

This means it is possible stay updated on the status of the plant around the clock.

In the event of a problem, it is possible react quickly and secure the total yields.

Parameters can be changed and a variety of measured values can be depicted, analyzed and downloaded via a web browser.

All data from the connected devices will be stored and automatically transmitted to a manufacturer portal if desired.

Other features are:

- Remote PV plant monitoring, diagnosis and configuration
 - Data logger for all key plant data
 - Rapid detection of operation failures
 - Automatic monitoring of all inverters via RS485
 - Quick set-up thanks to the Sunny WebBox Assistant and quick reference guide
 - Includes free standard access to Sunny Portal for the entire service life of the plant
 - Flexible display, evaluation, yield and event reports via Sunny Portal
- **Decoupling protection and device**

In order to protect the system from network failures a decoupling device and protection shall be provided.

The device consists of an instantaneous contactor relay controlled by the decoupling protection through the output contacts of the relays.

It consists of the following relays:

- True RMS 3-Phase, 3-Phase+N
- TRMS 3-phase over and under voltage, over and under frequency, phase sequence and phase loss monitoring relay
- Detect when all 3 phases are present and have the correct sequence
- Detect if all the 3-phase-phase or phase-neutral voltages are within the set limits
- Detect if the system frequency is between the set limits
- Separately adjustable set points
- Separately adjustable delay functions (0.1 to 30 s)
- Output: 2 x 8 A relay SPDT
- LED indication for relays, alarm and power supply ON
- 3-phase or 3-phase+neutral line voltage monitoring relays for phase sequence, phase loss, over and under voltage (separately adjustable set points), over and under frequency with built-in time delay function. Supply ranges from 208 to 690 V AC covered by four multi-voltage relays. Connected to the 3 phases (and neutral) operates when all 3 phases are present at the same time and the phase sequence is correct.
- Voltage and frequency level monitoring: if one or more phase-phase or phase-neutral

voltage exceed the upper set level or drop below the lower set level the respective output relay releases after the set time period. If the mains frequency gets out of the symmetrical window across the nominal frequency the grid the respective output relay releases after the set time period.

22.4.6.11 Solar energy DC cables

Solar energy cables (also known as Photovoltaic or PV cables) shall be manufactured in accordance with various British and International Standards.

The outdoor cable range shall be designed to withstand severe environmental conditions and degradation from UV light exposure.

Solar cable shall be suitable for a range of applications including providing the interconnection of photovoltaic power generation systems such as the solar panel arrays.

The DC cables are FG21OM21 type with the following features:

- Conductor tinned copper, flexible,
- Insulation HEPR – type G21
- Core identification Natural color
- Sheath Cross- linked elastomeric compound, halogen free, type M21
- Sheath-colors black, blue, red

22.4.6.12 AC cables

The single and multi-core AC cables are FG7OR type with the features as follows:

- Core Stranded flexible annealed bare copper conductor
- Insulation High module HEPR rubber,
- Sheath Special PVC grey outer sheath, Rz type with coloured line
 - Sheath-colours light blue-brown black-grey-yellow/green-brown-black-grey

The neutral type conductor shall be light blue.

The earth protection and bonding conductors shall be yellow-green.

The single core AC cables are NOV7-K Type with the following characteristics:

For terminal circuits and earth protective conductor N07V-K type will be provided.

- Core Flexible stranded annealed bare copper conductor
- Insulation PVC, R2 type
- New double layer formation Softer inner layer - Abrasion-resistant outer layer
- Superior performance Easy to handle, excellent sliding properties during conduit installation, high resistance to abrasion, easy stripping
- Range of colours Black, brawn, light blue, grey, red, white, yellow/green, orange, pink, dark blue, violet
- Marking Embossing on insulation each 0,5 meter interval

For earth protective conductor the color is yellow/green.

22.4.6.13 Earthing and bonding

Earthing system installation shall comply with the standards & regulations. Bonding of all metal parts shall be included and surge arrestor shall be connected to the incoming.

The system should be applied on Faraday cage theory with its all requirements including flat steel galvanized tape, 50mm² radial bare copper wire, testing points, tap-off, equipotent bus bars, inspection manholes and digging of three 19mm diam. copper electrodes in each manhole.

The copper earthing ring should be connected together by thermite welding with using BURNDY thermo-weld molds and suitable sized cartridge.

When inspection earthing resistance, it must not exceed 1 ohm under any circumstances.

22.4.6.14 Handing-over

Before handing-over, the contractor shall submit the following documentation to the supervisor engineer:

- 1- At the completion of the work, the contractor shall return, a complete set of prints of the contract drawings, neatly marked up in red with all alterations made during the contract period. This set of prints is to enable the supervisor engineer to alter the original contract transparencies to the "as installed" state.
- 2- Complete set of as built drawings, operation and maintenance manuals in English and Arabic, and overhaul.
- 3- Electrical circuits diagrams for the whole system.
- 4- Specifications of all components used in the boards, such as photo-voltaic modules/panels, inverters, circuit breakers, contactors, fuses/switches, push buttons, auxiliary relays, measuring instruments etc.
- 5- Part lists with brochures.
- 6- Schedule for periodic maintenance for all instruments and equipment used in the work.
- 7- Training two staff at least, on operating and monitoring the overall system to satisfactory extent for the end-user.

22.4.6.15 Approval

Approval of electrical materials and equipment will be based on manufacturer's published data. Where materials or equipment specified to be constructed and/or tested in accordance with any National or International Standards, a proof of such conformance shall be submitted for approval as well as copies of the Standards. A reputable manufacturer's certified statement indicating complete compliance of each item with the applicable National or International Standards, or other commercial standard specified shall be submitted but will not be sufficient as proof of compliance. A certified copy of test reports to the referenced Standards shall be submitted to the Project Manager on his request. Conformance with the agency requirements does not relieve the item from complying with any other requirements of the specifications.

22.4.6.16 Ambient Design Conditions

System design as well as material and equipment ratings will conform to the existing climatic conditions. Maximum ambient temperature is 45 °C in shade. Humidity range 24% - 90% Outdoor equipment will be subject to solar effects, blowing sand, dust, rain and in general the Mediterranean Sea Climatic Conditions.

22.4.6.17 Delivery

Deliver electrical materials and equipment in manufacturer's original cartons or containers with seals intact, as applicable unless otherwise specified, deliver conductors in sealed cartons or on sealed

reels, ends of reeled conductors factory sealed. Deliver large multi-component assemblies in sections that facilitate field handling and installation.

22.4.6.18 Handling

Handle materials and equipment in accordance with best industry practices and manufacturer's recommendations. List large or heavy items only at the points designed by the manufacturer. Use padded slings and hooks for lifting as necessary to prevent damage.

22.4.6.19 Storage

Store all electrical materials and equipment off the ground and under cover. Prevent corrosion, contamination or deterioration. Unless the equipment item is specifically designed for outdoor exposure in a non-operating mode, all items shall be stored in a protected environment.

22.4.6.20 Protection

Provide protection of electrical materials and equipment until final acceptance. Protect factory painted surfaces from impact, abrasion, discoloration and other damage keep electrical equipment, materials and insulation dry at all times. If partial dismantling of equipment is required for installation, box or wrap the removed parts until reinstalled.

22.4.6.21 Standard Products

Materials and equipment to be provided shall be essentially the standard catalogued products of a manufacturer regularly engaged in the manufacture of the products for at least 10 years. Materials and equipment shall meet the applicable requirements of the specification, and shall essentially duplicates material and equipment that have been in satisfactory use at least 2 years.

22.4.6.22 Prohibited Materials

Aluminum conduits, fittings supports and conductors are not acceptable unless specially approved for each use and location.

22.4.6.23 Factory Finishes

Unless otherwise specified in a specific Technical Provisions section, the sheet metal surfaces of electrical equipment enclosures shall be Galvanized and coated with a rust resistant primer over the primer apply a corrosion-resistant asked enamel finish on interior and exterior metal surfaces. The color shall be medium light Grey Hardware shall have a corrosion-resistant finish.

All metallic materials shall be protested against corrosion. Aluminum shall not be used. All ferrous metals such as anchors, bolts, braces, boxes, bodies, clamps, fittings, guards, nuts, pins, rods, shims, thimbles, washer's, and miscellaneous parts not of corrosion resistant steel, shall be hot dip galvanized except where other equivalent protective treatment is specifically approved.

22.4.6.24 Execution

Install of electrical work in accordance with the Regulations and Standards specified except where more stringent requirements are indicated or specified. Verify that materials and

Equipment properly fit the installation space with clearances comforting to the Regulations and Standards specified except where greater clearance is indicated perform work as required to correct improper installations, at no additional cost to the Employer.

The Contractor shall provide and install power wiring for all fixed electrical equipment complete and ready for operation including load break switches. Throughout the course of the work the supervisor engineer may request minor changes and adjustments to drawings and Specifications. The contractor shall make such adjustments without additional cost to the Employer where such minor adjustments are necessary to the proper installation and operation of the work and are within the intent of the contract documents.

22.4.6.25 Warranty

Provide a two-year warranty for equipment specified in this contract.

22.4.6.26 TESTING AND INSPECTION

The contractor shall provide all necessary testing equipment as required by the supervisor engineer to carry-out tests as set out in the Regulations and as required by the relevant Electricity Authority.

The contractor shall also be responsible for the payment of fees to specialists and manufacturers, for testing and commissioning required to bring all such plant and equipment into fully efficient operation as part of the installation.

The contractor shall thoroughly test each section of the contract works all generally in accordance with I.E.E. and Electricity Authorities regulations, and the tests shall include the following.

- Insulation resistance tests between earth and each phase on all circuits and power consuming equipment by means of a 500 Volt insulation tester. During the test all lighting switches shall be turned.
- All insulation tests shall be made between phases, between each phase and earth, and between earth and neutral with the controlling switch neutral link removed.
- Insulation tests shall be repeated between phases and between each phase and neutral with all switches off and all lamps removed.
- Insulation resistances below 10 mega-ohms will not be accepted.
- Earth continuity tests shall be made on each main, sub-main, circuit and sub-circuit.
- Polarity of switches and continuity of ring main circuits shall be tested .
- Insulation resistance tests of all connected appliances shall be made .
- Tests of the effectiveness of earthing including resistance of main earth shall be made.

Any other tests the supervisor engineer may reasonably instruct the contractor to make. Such will include readings of potential drop and current balance between phases at full load conditions at various points in the installation.

The contractor is to provide all necessary labor, materials, test media and instruments required and all instruments must carry a recent calibration certificate from an approved body.

All tests are to be witnessed by the supervisor engineer, and triplicate test record certificates, signed by all test witnesses, are to be provided to the Project Manager as the work proceeds, upon request, or in any event before the commencement of the Maintenance Period.

At least 7 days written notice is to be given of intention to perform any test.

In addition to installation and testing, the sub-contractor has to carry-out operation testing of all sections, clean, set, calibrate and fully commission, demonstrate and hand over the entire contract works in a thoroughly complete and operational state to the satisfaction of the supervisor engineer.

The contractor has to present a list of tests which will be done for the equipment, and to be approved by the supervisor engineer. The contractor has to carry-out all workshop tests mentioned and required in the coming sections of this specifications and as recommended by the manufacturer.

22.4.6.27 Distribution System

Before completion, the installation shall be tested in accordance the standards, and to be demonstrated compliance with the Regulations, and in accordance with the requirements of the supervisor engineer.

Inspections will be carried-out during installation and after completion of work.

All assistance in the form of Labor and instruments for carrying-out such tests and inspections shall be supplied by the contractor at reasonable times as required by the supervisor engineer and the costs of such tests shall be included in the prices quoted by the contractor for the various items to be installed under the specification.

All cables and cable sheaths shall be tested for continuity and insulation resistance as the work proceeds and before connecting to the main supply.

The Testing procedures shall be performed for as the followings:

- i. That the equipment complies with the specification.
- ii. That the installations comply with the Regulations (Latest Edition), the Electricity Supply Regulations, Licensing Authorities and Fire Regulations where applicable.
- iii. Earth resistance testing.
- iv. That all protective devices are correctly adjusted and operated satisfactorily.
- v. Contactor's overload continuity and activity
- vi. Measurement of Insulation Resistance
- vii. Check of Protection by barriers and Enclosures.
- viii. Measurement of the insulation of conducting and non-conducting floors and walls.
- ix. Verification of Polarity
- x. Measurement of Earth Fault Loop Impedance
- xi. Test of Operation of Residual Current Devices
- xii. Tripping times of residual Current devices.
- xiii. That the polarity of all switches, circuit breakers and the phase rotation of the respective systems are correct.

All the above shall be carried out in accordance with the Regulations. The contractor must show for each procedure and calculation, the Project Manager after completion of each test.

Caution must be exercised in testing PROJECT.

After completing each part of the installation and after carrying out the above tests the contractor shall switch on all electrical loads. The current in each phase shall be measured with a clip-on ammeter and if an imbalance of more than 10% exists, reconnections shall be made to balance the load. Before final test is carried-out on the whole or part of the installation, the contractor shall switch on all of the installation, which is completed at that time. He shall switch on all loads and run the installation for a minimum period of three hours, at 1/3 full load and minimum period of a half-hour at full load. Test certifications shall be of the formed and specified.

Phase sequences shall be tested at each distribution board; the tests shall show that the phase sequence and color-coding is constant throughout the installation, the sequence being R.S.T.

Tests shall be made during and after installation to demonstrate that the phase rotation is correct at all end connections of power cables.

Where electronic equipment is installed, care must be taken when testing to avoid damage due to testing voltages. If necessary, vulnerable devices and equipments must be disconnected.

The Contractor shall also include in his tender for demonstrating satisfactory operation of any section, of the installation to external authorities such as Fire Officers, Factory Inspectors, Licensing Authorities, Insurance Company Representatives.

If any defects occur to any section or the installation after commissioning, the Project Manager preserves the right to call for such further tests as may be necessary to identify the nature and location of the defect, and to demonstrate the satisfactory completion of the remedial works. The Contractor shall bear all costs involved in carrying out the additional testing.

22.4.6.28 Tests Certificate

The tests shall be for electrical tests, to demonstrate satisfactory operation of the equipment. Where protection relays or adjustable over current trips are incorporated, primary injection tests shall be carried-out to demonstrate the correct setting of the protection device and its satisfactory operation. Tests certificates shall be obtained from the testing authorities, and issued by the Contractor when primary tests are carried-out.

22.4.6.29 Earth Testing

Earth continuity and earth electrodes shall be tested in accordance with the Standard Code of practice CP 1013. It is to be noted that tests of earth continuity and the earth electrodes must be carried out and the system proved satisfactory before any section of the installation is energized

The insulation resistance of lighting single-phase power and 380V three-phase power installations shall be measured with a 500 volt insulation-testing instrument.

Tests of insulation resistance for lighting and single phase power installations shall be carried out by disconnecting circuit leads from the neutral bar, tripping the MCBs and applying the testing voltage between the distribution board case and the disconnected neutral conductor.

In the case of single-phase power installation all portable apparatus shall be disconnected.

In addition, the testing voltage shall be applied between the respective phase conductors at the MCB terminals and between each phase and the neutral conductor.

22.4.6.30 Surge protective device

Upstream to the inverters inside the string boxes the SPD DEHN GUARD MY SCI 1000 type with the following characteristics will be provided:

Modular multi-pole surge arrester with three-step d.c. switching device.

Type 2 SPD according to EN 50539-11.

Pre-wired, modular complete unit for use in photovoltaic systems consisting of a base part and plug-in protection modules.

Combined disconnection and short-circuiting device with safe electrical isolation in the protection module prevents fire damage due to d.c. arcs.

Tried and tested fault-resistant Y circuit prevents damage to surge protective devices in case of insulation faults in the generator circuit.

Integrated d.c. fuse allows safe replacement of protection modules without arc formation.

Tested to EN 50539-11.

Suitable for use in all PV systems according to IEC 60364-7-712.

Short-circuit current rating ISCPV: 1000 A.

DATA SHEET

SPD according to EN 50539-11	type 2
Max. PV voltage (UCPV)	$\leq 1000 \text{ V}$
Short-circuit current rating (ISCPV)	1000 A
Total discharge current (8/20 μs) (I_{total})	40 kA
Nominal discharge current (8/20 μs) [(DC+/DC-) --> PE] (I_{n})	12.5 kA

Max. discharge current (8/20 μ s) [(DC+/DC-) – -> PE] (Imax)	25 kA
Voltage protection level (UP)	≤ 4 kV
Voltage protection level at 5 kA (UP) ≤ 3.5 kV	≤ 3.5 kV
Response time (tA) ≤ 25 ns	≤ 25 ns
Operating temperature range (TU)	-40 °C ... +80 °C
Operating state / fault indication	green / red
Number of ports	1
Cross-sectional area (min.)	1.5 mm ² solid / flexible
Cross-sectional area (max.)	35 mm ² stranded / 25 mm ² flexible
For mounting on	35 mm DIN rails acc. to EN 60715
Enclosure material	thermoplastic, red, UL 94 V-0
Place of installation	indoor installation
Degree of protection	IP 20
Capacity	3 module(s), DIN 43880
Approvals	KEMA, UL, CSA
Weight	340 g

22.4.6.31 Surge protective device

TYPE 1

Upstream to the General Device Type 1 surge protective DEHNVENTIL 255TT device will be provided.

Combined lightning current and surge arrester based on RADAX Flow spark gap technology

Fully compliant with all requirements of the national VDN* guideline on the use of SPDs upstream of the meter

Quick and easy installation by snapping the arrester onto 40 mm bus-bar systems

Test for correct operation by pressing the button with indicator light

No tripping of 32 A gL/gG fuses up to short-circuit currents of 25 kA_{ms}

Discharge capacity up to 100 kA (10/350 μ s)

Capable of protecting terminal equipments

DATA SHEET

SPD according to EN 61643-11	Type 1
SPD according to IEC 61643-1/-11	Class I
Energy coordination with terminal equipment	Type 1 + Type 2
Energy coordination with terminal equipment (≤ 5 m)	Type 1 + Type 2 + Type 3
Nominal a.c. voltage (Un)	230 / 400 V
Max. continuous operating a.c. voltage (UC)	255 V
Lightning impulse current (10/350 μ s) [L1+L2+L3+N-PE] (I total)	100 kA
Specific energy [L1+L2+L3+N-PE] (W/R)	2.50 MJ/ohms
Lightning impulse current (10/350 μ s) [L-N] (I _{imp})	25 kA
Specific energy [L-N] (W/R)	156.25 kJ/ohms

Lightning impulse current (10/350 μ s) [N-PE] (Iimp)	100 kA
Specific energy [N-PE] (W/R)	2.50 MJ/ohms
Nominal discharge current (8/20 μ s) (In)	25 / 100 kA
Voltage protection level [L-N] (UP)	≤ 1.5 kV
Voltage protection level [N-PE] (UP)	≤ 1.5 kV
Follow current extinguishing capability [L-N] a.c. (Ifi)	25 kArms
Follow current extinguishing capability [N-PE] a.c. (Ifi)	100Arms
Follow current limitation/Selectivity	no tripping of a 32 A gL/gG fuse up to 25 kArms
Response time (tA)	≤ 100 ns
Max. backup fuse up to IK = 25 kArmsKK	315A gL/gG
Max. backup fuse for IK > 25 kArms	200A gL/gG

TYPE 2

On the secondary panels Type 2 surge protective device Dehnguard DGMTT275FM will be provided.

Modular multipole surge arrester with a functional design.

For protecting low-voltage consumer's installations against surges.

For installation in conformity with the lightning protection zones concept at the boundaries from 0B – 1 and higher.

SPD Type 2 according to EN 61643-11

Complete prewired unit, consisting of a base part and plug-in protection modules.

Energy coordination with other arresters of the Red/Line product family.

High discharge capacity due to heavy-duty zinc oxide varistors/spark gaps.

High reliability due to "Thermo Dynamic Control" SPD monitoring device.

Easy replacement of protection modules without tools due to module locking system with module release button

Vibration and shock-tested according to EN 60068-2

DATA SHEET

SPD according to EN 61643-11	Type 2
SPD according to IEC 61643-1/-11	Class II
Nominal a.c. voltage (UN)	230/400 V
Max. continuous operating a.c. voltage [L-N] (UC)	275 V
Max. continuous operating a.c. voltage [N-PE] (UC)	255 V
Nominal discharge current (8/20 μ s) (In)	20 kA
Max. discharge current (8/20 μ s) (Imax)	40 kA
Lightning impulse current (10/350 μ s) [N-PE] (Iimp)	12 kA
Voltage protection level [L-N] (UP)	≤ 1.25 kV

Voltage protection level [L-N] at 5 kA (UP)	≤ 1 kV
Voltage protection level [N-PE] (UP)	≤ 1.5 kV
Follow current extinguishing capability [N-PE] (Ifi)	100 Arms
Response time [L-N] (tA)	≤ 25 ns
Response time [N-PE] (tA)	≤ 100 ns
Max. mains-side overcurrent protection	125 A gL/gG
Short-circuit withstand capability for max. mains-side overcurrent protection	50kArms
Temporary overvoltage (TOV) [L-N] (UT)	335 V / 5 sec..
Temporary overvoltage (TOV) [N-PE] (UT)	1200 V / 200 ms
TOV characteristic	withstand
Operating temperature range (TU)	-40°C...+80°C
Operating state/fault indication	green / red

22.4.6.32 CABLE TRAYS & CABLE LADDERS

On the cover close to the photovoltaic modules hot dipped galvanized after manufacture wire mesh cable trays will be provided with cover.

The cable trays or accessories, manufactured by untreated steel sheet or wire, are degreased and pickled before being immersed in a bath of molten zinc.

The entire product is therefore covered with a thick layer of zinc.

A light grey, rough appearance is obtained.

Advantages:

- Fast and easy mounting with simple tools
- Could be adapted to any obstacle to build the installation
- Small own weight and big carrying capacity
- Specially designed edges to prevent hand wound and wire & cable damage during installation
- The open design allows the visual control of the cables
- The open wire-mesh structure reduces cable heating and allows the use of cables with smaller section
- Proven quality

23 -DIESEL GENERATOR

The following is a specification for generator to be supplied and installed as a part of this contract.

23.1 Standards

The equipment and performance shall be in accordance with the following regulations.

BS4999/ 5000 Part 99, VDE 0530, UTE5100, NEMA MG1.22, CEMA, IEC34, CSAA 22.2 as 1359, BS5514, DIN6271 and JSO3046.

23.2 General

One automatic start sound attenuated weather proof generator unit shall be supplied and installed complete with exhaust silencers and controls.

The set shall be designed to give a supply at a voltage of 380 volts 50 Hz 3 phase 4 wire and be of the totally self-contained design incorporating a diesel engine prime mover, self-existing alternator and electric starter unit.

The set shall be arranged to start automatically and run up to full speed within 15 seconds.

The complete unit shall be maintained on a prefabricated skid base- frame with anti-vibration mountings, the whole unit arranged to bolt on to prepared concrete foundations.

23.3 Engine

The engine shall incorporate the following features.

- a. Tropical radiator suitable for 50 c
- b. Battery charging alternator
- c. 12 volt electric starter
- d. 12 volt fuel solenoid
- e. Heavy duty lead acid batteries (12V)
- f. Battery rack and fitted cables
- g. Spin- on full flow lubricating oil filters
- h. By- pass lube oil filter
- i. Spin- on paper element fuel filters
- j. Oil cooler and gear pump
- k. Lube oil drained piped to chassis
- l. Fan and pulley guard protection
- m. Self-adjusting fuel system
- n. Fuel pump and twin flexible fuel lines
- o. Heavy duty air cleaner (s) (dry)
- p. Exhaust silencer with flanges
- q. EFC (Electronic Fuel Control)
- r. Instruction and operating manuals
- s. Automatic engine protection system
- t. Low oil pressure
- u. High water temperature
- v. Over speed protection
- w. Visual alarm indication and automatic engine shut down

23.4 Chassis

A robust heavy duty fabricated chassis complete with lifting points, anti-vibration mountings, bolt down holes.

An eight-hour daily service fuel tank and hand operated rotary fuel transfer pump shall be provided.

23.5 Alternators

The alternator shall incorporate the following features:

- a. Brushless, single-bearing and four pole
- b. Screen protected and drip proof
- c. Enclosed to IP22 (MEMA1) standard
- d. IC 01 cooling system
- e. Fully interconnected damper windings
- f. AC exciter and rotating rectifier unit
- g. Epoxy coated stator windings
- h. Rotor and exciter impregnated with tropical grade insulating oil and acid resisting polyester resin. Dynamically balanced rotor to BS5625 grade 12.5
- i. Sealed for life bearings
- j. Layer wound mechanically wedged rotor
- k. Insulation to class H
- l. Exciter: triple dipped in moisture, oil and acid resisting polyester varnish
- m. Sealed solid state automatic voltage regulator – self exciting, self-regulating
- n. Output windings with 2/3 pitch
- o. Close coupled engine/ alternator

23.6 Voltage Regulation

Maintains voltage output to within $\pm 1.5\%$ or $\pm 1\%$ at any pf between 0.8 lagging and unity, at any variations from no load, cold to hot and including speed droop variations at 4.5%.

Voltage trimmer on AVR for adjustment.

23.7 Waveform

Total harmonic distortion open circuit voltage waveform in the order of 1.5%. Three phases balanced load in the order of 3.5%.

23.8 Telephone Interference

THF better than 50.

23.9 Radio Interference

Suppression to VDE class G and N.

23.10 Motor Starting

Shall withstand a short-term overload between 200% to 300% full load impedance depending on frame size and AVR used.

23.11 Voltage Surges

Surges suppressor fitted protecting exciter rectifier against short circuits or out of phase paralleling.

23.12 Frequency Regulation

$\pm 0.25\%$ steady state load.

23.13 Generator Controls

Control Panels

The control cubical shall be accessible through a top removable panel with cable glands provided in the base and rear of the panels.

Instrumentation

- 3 - Ammeters 72mm quadrant scale or 100mm Dai
- 3 - Current transformers
- 1 - Voltmeter 72mm quadrant scale
- 1 - Voltmeter seven – position selector switch
- 1 - Frequency meter 72mm quadrant scale
- 1 - Hours run counter 48m sq. 10,000 hours and tenths
- 1 - Set of five front access instrument fuses
(Preferred to use digital display)

Comprehensive Control System

Four-position mode selection switch.

1. Test on load – start and load take – over
2. Test off load – start and run – no load change – over
3. Normal – alter status with auto start on supply failure
4. Off set cannot be started. Stop control and reset position

Illuminated heater switch – mains operated to thermostatically controlled engine heater.

Three-phase sensing units with close tolerance and phase displacement sensing. Set of running detection units – monitoring the alternator frequency and engine charge alternator.

Fail to start lock – out unit.

Transfer System and Timers

Transfer delay inhibitor and protection unit re- transfer delay timer for mains return. Run – on 0-6 min timer for delay – on stop.

Contactors will not change – over until monitored voltage and frequency attain correct rating. Transfer shall then be activated. Adjustable timers shall be pre – set at factory.

If public power supply returns during start sequence the system shall abort starting and return to normal.

If mains fail again during a run – on time delay the set shall immediately take over the load.

Programmed Timers

	E	F
Start solenoid function	0	0
Start pulse	5	4
Start pulse reset	1	3
Start delay	0	2
Lock – out	1	5
Over speed protection	0	0

Repeat Starting Protection

Three repeat starting attempts shall be incorporated. The engine shall be automatically cranked for a pre- set adjustable period with pre- set times rest periods between each attempt.

“Failed to start” visual indicator illuminates for fault identification.

Protection Systems

Automatic set shut down shall take place in the event of:

- Over- voltage
- Over speed

Cooling fault
Low oil pressure

Alternator contactors will trip out in the event of low voltage, low frequency, and over- voltage or over speed.

Alarm and Status Indicators

Indication LEDs shall show for the following:

- Alarms
- Low alternator voltage and/ frequency:
- High alternator volts
- Low oil pressure
- High engine temperature
- Battery charging alternator fault
- Over speeds failure
- Fail to start
- Status
- Mains on load
- Mains in limits
- Set on load
- Cooling run operational – delay on stop
- Battery DC on – system operational

Alarms shall automatically latch once activated.

Set Testing

Mode selector switch in “test off load” position can be used for mains failure and anticipated sequence testing.

Test on load- full mains failure start and change – over sequence

Automatic Battery Charging

An automatic fully regulating, constant voltage, current limiting battery charger of solid-state construction shall provide for starter batteries when mains supply is available.

Alternator battery charging when set is running.

Quick Fuse Replacement

Front access DC and AC HBC instrument and circuit fuses clearly identified shall be positioned on the panel facial.

Integral Circuit Breaker

The vibration isolated steel cubical shall contain a fully connected three pole molded case circuit breaker with thermal and magnetic overload and short circuit tripping protection.

Plant and Load Protection

The generator standby contactors shall automatically trip out in the event of under speed, under-voltage, over- voltage, or over speed. Individual LED visual indicators shall identify the cause of malfunction.

Fast Track Wiring

All AC and DC control wiring shall be clearly identified with coded ferrules at each termination permitting fast fault finding. Plant wiring shall be fully sleeved, cleated and anchored.

Full Automatic Operation

The system, when alert status, shall sense a transient, a permanent fall, or a complete failure of the supply voltage on one or more phases of a pre- set value from –1% to –20% of the nominal voltage value.

Subject to the preprogrammed time delay settings, a start command signal shall initiate the automatic starting sequence and the multi- set programmer. Once the engine has started, the alternator frequency and voltage shall be checked prior the contactors closure. This ensures correct levels have been attained.

Time from power failure to take- over shall be a maximum of 15 seconds.

Automatic Load Transfer Panel

Imbedded in the main distribution board, change- over contractors comprising:

One pair of mechanically and electrically interlocked, four-pole change – over contractors. One set of AC and DC terminals to interface with generator control panel. Cable gland plate fitted for incoming cable clamping.

Clear Facial Instruction

All operating and fault and status instructions shall be screen-printed either white on black or red on white onto the panel facial.

Equipment Finish

All sheet metal shall be zinc – coated prior to an application of a self- etching primer. The pre-treated and pre- painted engine/ alternator power pack and the whole unit shall be finished off with an electronically sprayed final coat of high quality gloss paint.

Wide Temperature Tolerance

Control system designed to operate over the temperature range – 0C TO +75C up to 95% relative humidity.

23.14 Louvers

Louvers shall be provided with suitably sized inlet and outlet areas to suit the selected equipment characteristics and also to suit the requirements of the architect where penetrations are involved. The louvers shall be movable blades with engine air pressure.

23.15 Main Duty Oil Tank

Oil shall be taken from the central oil storage tank, all connections and safety controls between the tank and the generator shall be included as part of this works.