



UNITED NATIONS HIGH COMMISSIONER FOR REFUGEES (UNHCR)

RENOVATION/MAINTENANCE WORKS AT UNHCR OFFICE SECTOR G-4, ISLAMABAD

CAR PARKING SHED

TECHNICAL SPECIFICATIONS

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CIVIL WORKS

SECTION - 1100

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SECTION – 1100

EARTHWORKS

1.0 SCOPE OF WORK

The work under this section of the specifications consists of furnishing all plant, labour, equipment, appliances and materials and in performing all operations for excavation, backfilling, construction of embankments and disposal of unsuitable and surplus excavated material as required in accordance with this section of specifications, the applicable drawings and subject to terms and conditions of the Contract.

2.0 APPLICABLE STANDARDS

Materials, construction and testing shall comply with the following codes and standards:

ASTM C 136	Sieve or screen analysis of fine and coarse aggregate
ASTM D 422	Testing for Liquid Limit of Soils
ASTM D 424	Testing for Plastic Limit and Plasticity Index on Soils
ASTM D 596	Water Analyses
ASTM D1556	Density of soil in place by the sand cone method
ASTM D1557	Moisture-Density relation of soils using 4.5kg rammer and 457mm drop
ASTM D 2167	Density of soil in place by the Rubber-Balloon method
ASTM D 2216	Moisture content of soil
ASTM D 4253	Test method for maximum Index Density and unit weight of soils
ASTM D 4254	Test method for minimum Index Density and unit weight of soils
ASTM D 1883	CBR-California Bearing Ratio test

3.0 GENERAL

- 3.1 The Contractor shall acquaint himself with the nature of the ground, existing structures and subsurface materials (soil / rock) which will be encountered during excavation or earthworks. The Employer does not guarantee or warrant in any way that the materials to be found in the excavation will be similar in nature to that of any samples which may have been exhibited or indicated in the Report, Drawings or any other Contract Documents or to material obtained from boring or trial holes. The Contractor shall be deemed to have made local and independent inquiries as to, and shall take whole risk of the nature of the subsurface materials (soil / rock) to be excavated or penetrated and the Contractor shall not be entitled to receive an extra or additional payment nor to be relieved from any of his obligations by reasons of the nature of such ground and subsurface material.
- 3.2 The Contractor shall submit a detailed list of plant and equipment which he shall undertake to bring to the site and to carry out the work. The list shall satisfy the Engineer as to type, size and quantity. The Contractor shall place on the site of the work all of the equipment listed and all subsequent equipment required for approval of the detailed program of work and such equipment which may be directed by the Engineer. All equipment which is proposed to be used on the work shall be sufficient size and in such mechanical condition as to meet requirement of work and produce a satisfactory quality

of work. In no case shall the Contractor remove from the site the plant and equipment without the written approval of the Engineer. The Contractor shall supply all plant and equipment necessary for the construction of each phase of the work and it must be on site, inspected and approved by the Engineer. If after use of the equipment the Engineer determines that the work provided does not meet the Contract requirement, the equipment shall be changed and the deficient work shall be removed and corrected as directed by the Engineer.

- 3.3 All suitable materials from stripping of top soil and excavation shall be used unless otherwise declared unsuitable by the Engineer. The suitable material shall comply with the requirements as specified in the respective clauses for various items.
- 3.4 The Contractor shall jointly survey the area marked for pavements utilities, service lines, buildings or other structures or any area designated by the Engineer and prepare the survey drawings showing natural ground profile and cross-section and submit to the Engineer for approval prior to start of any earthwork operation.

All suitable material from excavations shall be transported to and placed in fill areas or stockpiled at locations designated by the Engineer. Materials from excavation and stripping shall be stockpiled separately.

Existing utilities which are to remain in service or to be relocated and to remain in service until relocation are to be determined by the Contractor. They shall be safeguarded and protected from damage.

If any existing service lines, utilities and utility structures which are to remain in service are uncovered or encountered during the operations, shall be safe guarded, protected from damage and supported as directed by the Engineer.

- 3.5 All excavations, cut and fills shall be constructed to the lines, levels and gradients specified with any necessary allowance for consolidation, settlement and drainage so that at the end of the Period of Maintenance the ground shall be at the required lines, levels and gradients. During the course of the Contract and during the Period of Maintenance any damage or defects in cuts and fills, in structures and other works, caused by slips, falls of wash-ins or any other ground movement due to the Contractor's negligence shall be made good by the contractor at his own cost.

4.0 **SITE PREPARATION**

- 4.1 The Contractor shall set out the works and shall be responsible for true and perfect setting out of the same and for correctness of the positions, levels, dimensions and alignments of all parts thereof. If at any time any error in this respect shall appear during the progress of the works, the Contractor shall at his own expense rectify such error, to the satisfaction of the Engineer.
- 4.2 The Contractor shall construct and maintain accurate bench marks so that the Lines and Levels can be easily checked by the Engineer.
- 4.3 The Contractor shall construct and maintain such temporary drains in addition to those shown on the plans, as will adequately drain areas during construction.
- 4.4 The Contractor shall perform a joint survey with the Engineer's Representative, of the area where earth work is required, plot the ground levels on the drawings and obtain approval from the Engineer before starting the earth work and shall supply a copy to the Employer duly checked, signed and authenticated by the Engineer before start of work.

5.0 CLASSIFICATION OF EXCAVATION

- 5.1 No classification shall be made of any material excavated / cut as to its class, nature, origin or condition. The excavation will be unclassified as being carried out in all kinds of subsurface material including soil and rock.

Blasting will be permitted only when proper precautions are taken for the safety of all persons, the work, and the property. All damage done to the work or property shall be repaired at the Contractor's expense. All operations of the Contractor in connection with the transportation, storage, and use of explosives shall conform to all state and local regulations and explosive manufacturers' instructions, with applicable approved permits reviewed by the Engineer. Any approval given, however, will not relieve the Contractor of his / her responsibility in blasting operations.

In each distinct blasting area, where pertinent factors affecting blast vibrations and their effects in the area remain the same, the Contractor shall submit a blasting plan of the initial blasts to the Engineer for approval. This plan must consist of holes size, depth, spacing, burden, type of explosive, type of delay sequence, maximum amount of explosive on any one delay period, depth of rock and depth of overburden if any. The maximum explosive charge weights per delay included in the plan shall not be increased without the approval of the Engineer.

The Contractor shall keep a record of each blast fired – its date, time and location; the amount of explosives used, maximum explosive charge weight per delay period, and, where necessary, seismograph records identified by instrument number and location.

The excavation wherever required will be carried out below ground water level by dewatering the area.

The Contractor shall build, maintain and operate all berms, channels, flumes, sumps and other temporary diversion and protective works needed to divert the surface water through or around the required excavation. All excavation shall be dewatered and kept free of standing water, water seeping from the sides and bottom of excavation above, the free level. The Contractor shall furnish, install, operate and maintain all drains, sumps, pumps and other equipment needed to dewater the excavation areas. Dewatering methods that cause a loss of fines from the bottom and slopes of the excavation will not be permitted.

Prior to commencement of the work, the Contractor shall furnish the Engineer for review and comments with complete plans and sketches for diverting surface water if any and dewatering of the required excavation.

Submission for review and comments of the required plans and sketches and any approval from Engineer shall not relieve the Contractor of any of his duties and obligations under the contract.

5.2 Tolerance

In those areas upon which a sub-base or base course is to be placed, the top of the subgrade shall be of such smoothness that when tested with a 4.8 m (15.75 ft.) straight edge applied parallel and at right angles to the centerline, it shall not show deviation in excess of 12 mm (1/2") or shall not be more than 16 mm (5/8") from line grade as established by grade hubs or pins. Any deviation in excess of these amounts shall be corrected by loosening, adding, or removing material; reshaping; and recompacting by sprinkling and rolling.

On graded strips (safety areas) intermediate and other designated areas, the surface shall be of such smoothness that it will not vary more than 30 mm (1-1/4") from true grade as established by grade hubs.

6.0 EMBANKMENT CONSTRUCTION

6.1 General

It shall consist of construction of select embankment for paved areas and common embankment for unpaved areas. Only approved material shall be used in the construction of embankments.

All embankment construction shall be made to the lines, levels, profiles and grades as shown on the drawings or established by the Engineer. During progress of the work it may be found necessary or desirable by the Engineer to vary the levels, elevations and grades from those shown on the drawings. The Contractor shall perform the embankment construction to the revised levels, elevation as established by the Engineer.

Where embankments are to be placed in water logged areas and which are inaccessible to heavy construction equipment, a working platform shall be first established, consisting of a blanket of fill material placed on the water logged area. The thickness of the working platform shall be about 0.5 metres (1.65 feet) unless directed otherwise by the Engineer and the width shall be that of the embankment. The placement and compaction of the working platform shall be performed by use of light equipment as directed by the Engineer. No density requirements are specified for the working platform, however, subsequent layers above shall be compacted to densities specified in the relevant items.

Benching of sufficient width for slope stability and movement of equipment and machinery shall be carried out for embankment formation in areas of steep slopes.

6.2 Select Embankment

The select embankment shall be constructed under all paved areas. The area shall be prepared (after stripping of top soil) by scarifying the surface to a minimum depth of 150 mm (6") and compacting it to densities mentioned in subsection 6.2.2.

6.2.1 Material

The suitable subsurface material obtained from excavation (except top soil) shall be used in the construction of select embankment. The material shall be A-4 or superior as per AASHTO soil classification. The soaked CBR of the material shall be equal to or greater than 6. In the top 30 cm (12 in.) the material shall be A-4 or superior and the $PI \leq 8$. When excavated material consists predominately of rock fragments of such size that the material cannot be placed in layers of the prescribed thickness without crushing, pulverizing or further breaking down the pieces, such material may be placed in layers not exceeding 60 cm (2 ft.) in thickness. Each layer shall be leveled and smoothed with suitable leveling equipment and by distribution of spalls and finer fragments of rock. These type lifts shall not be constructed above an elevation 150 cm (5 ft) below the finished sub-grade.

6.2.2 Formation of Embankment

Embankment shall be formed in successive horizontal layers of not more than 200 mm (8 in.) in loose depth for the full width of the cross-section, unless otherwise approved by the Engineer.

The material placed in layers and the sub-grade scarified shall be compacted to the density specified below:

Depth (cm) Below Subgrade Level		Percent of Max. dry Density as per ASTM D1557	
Cohesive Soil	Non-Cohesive Soil	Cohesive Soil	Non-Cohesive Soil
0 to 30	0 to 60	95%	100%
30 to 75	60 to 100	93%	95%
Over 75	Over 100	90%	90%

Sub-grade level is the surface on which the pavement structure will be placed.

The maximum density of sand (granular) material (if used) shall also be determined as per ASTM D4253. The higher of the two values obtained from ASTM D1557 and ASTM D4253 shall be used to check the relative compaction of the in place material.

The moisture content of the material should be controlled to within $\pm 2\%$ of the optimum moisture content. In order to achieve a uniform moisture content throughout, the wetting and drying of the material, and manipulation shall be required when deemed necessary. Also, the California Bearing Ratio test (ASTM D1883) may be conducted on soil if instructed by the Engineer.

The embankment formed by rock fragments of such size that the material can not be placed in layers of thickness prescribed without crushing, pulverizing or further breaking down the pieces, such material may be placed in layers not exceeding 60 cm (2 ft.) of loose measurement and compacted by vibrating roller with mass as specified hereunder:

Mass per metre width of Vibrating roll	Depth of fill layer	Number of passes of the roller on each layer
2300 – 2900 kg/m 1550-1950 lbs./ft.	40 cm 16 in.	5
2900 – 3600 kg/m 1950-2400 lbs./ft.	50 cm 20 in.	5
2600 – 4300 kg/m 1750-2900 lbs./ft.	60 cm 24 in.	5

The material shall be carefully placed in layer so that all larger stones will be well distributed and voids completely filled with smaller stones, small spall and soil to form a solid mass. After placing the rock material, surface shall be covered with fine material having thickness less than 20 cm (8 in.).

Material for each layer should be consolidated with heavy weight vibratory roller until settlement as checked between two consecutive passes of roller is less than 1% of the layer thickness. When rock to be incorporated in fill is composed largely of weak or friable material, the rock shall be reduced to a maximum size not exceeding 50% of the thickness of the layer being placed.

6.3 Common Embankment

6.3.1 Material

The area requiring common embankment, and other unpaved areas shall be constructed from the excavated soil and rock. The top soil obtained from stripping may be used at deeper level with the approval of the Engineer.

6.3.2 Formation of Embankment

Before placing and compacting the fill material the ground shall be scarified to a depth of 15 cm (6 in.) and compacted to a dry density of 90% as per laboratory compaction test method ASTM D1557. The moisture content of soil during compaction of scarified layer and successive layers shall be within $\pm 2\%$ of optimum moisture content before rolling to obtain the desired density results. The successive horizontal layers shall be formed in loose depth 200mm(8 in.) for the full width of the cross section unless otherwise approved by the Engineer. Each layer will be compacted to dry density of 90% as per laboratory compaction test method ASTM D 1557.

The layer thicknesses and compaction requirements shall be the same as specified under 'Select Embankment' for embankment formed by rock fragments.

No rock larger than 8 cm (3 in.) in any dimension shall be placed in top 30 cm (12 in.) of embankment unless allowed by the Engineer.

6.4 Tolerances

Select Embankment

The grade surface of each layer excluding final layer, shall be smooth and even and tolerance from required grade shall not be more than 19 mm (3/4 in.).

Common Embankment

The grade surface of each layer including the final layer, shall be smooth and even and tolerance from required grade shall not be more than 19 mm (3/4 in.).

6.5 Sub-grade Preparation in Cut

The area shall be prepared (after stripping of top soil) by scarifying the surface to a minimum of 150 mm (6 in.) and compacted to density mentioned in subsection 6.2.3. In case the material below Sub-grade level is not suitable (having PI >8) then a minimum of 30 cm (12 in.) of the soil shall be improved to PI ≤ 8.

The surface of the Sub-grade level (fill & cut) shall have the following tolerances:

- Plus : 0 mm (0 in.)
- Minus : 40 mm (1-5/8 in.)

7.0 QUALITY CONTROL

A testing program shall be submitted by the Contractor. Tests shall be performed by the Contractor to ensure compliance with the specifications as required. A copy of all test reports shall be submitted to the Engineer for approval. The test shall be performed in accordance with the following test procedures and frequency of testing.

Prior to construction of embankment, classification and compaction tests shall be carried out on stock-piled material obtained from stripping of top soil and excavated subsurface material (soil & rock). The tests shall be carried out as per ASTM 422, ASTM 424 and ASTM D 1557. A family of laboratory compaction curves as per ASTM D 1557 representing typical material shall be developed for the fill / backfill material.

The frequency of classification tests shall be for every 1000 cu.m / 35,000 Cft. of fill material. The Engineer may alter the frequency of testing depending on the type of material and variation encountered at site.

The field density tests shall be performed as per ASTM D 1556 or ASTM D 2167. The frequency of testing shall be as under:

Select Embankment

Area requiring 90% to 93% compaction – one test in every 500 m² / 5000 Sft. area in each layer

Area requiring 95% & 100% compaction – one test in every 300 m² / 3000 Sft. area in each layer

Common Embankment

Area requiring 90% compaction – one test in every 1000 m² / 10000 Sft. area

The average of four tests are required to be greater than the required compaction and not more than one test be 1.8% less than required percentage of compaction. This is for 100% compaction. For 95% to 90% compaction the following is required.

<u>%age Compaction</u>	<u>One test not less than</u>
95%	93.5%
90%	89.5%

8.0 EARTH WORK FOR STRUCTURES, STORM WATER DRAINS & CULVERTS

8.1 Excavation

Excavation, including dewatering where required, for building/related structures, culverts, storm water drains etc. shall conform to the elevations and dimensions as shown on the drawings and extend to a sufficient distance to permit placing and removal of concrete formwork or other construction.

When determined by the Engineer to be insufficiently firm, excavation bottoms shall be further excavated to reach firm ground or backfilled with suitable material and compacted to 95% of maximum dry density as per ASTM D-1557.

All excavations in foundations shall be taken as 150 mm (6 in.) above the final excavation elevations shown on the drawings and the last 150 mm (6 in.) shall be trimmed carefully to a smooth surface. Immediately after trimming to final elevation, a layer of blinding concrete shall be placed to thickness shown on the drawings.

8.2 Fill and Backfill for Structures, Storm Water Drains and Culverts:

8.2.1 After completion of foundation footings, foundation walls and other construction below the elevation of the final grades and prior to start of back-filling, forms shall be removed and the excavation shall be cleaned of trash and debris.

8.2.2 The backfilling/fill shall include filling under the floors where shown or required and around the foundations.

8.2.3 The backfilling/fill shall include loading, unloading transporting, placing, stacking, spread of earth, watering, rolling, ramming and compaction etc. complete as specified herein.

8.2.4 Filling in foundations shall be placed in 200mm (8 in.) loose layers and compacted at optimum moisture content by mechanical means or other means as approved by the Engineer.

8.2.5 Material for backfilling shall be as approved by the Engineer and compacted to produce insitu dry density not less than 95% of the maximum dry density as achieved by compaction test as per ASTM D-1557.

9.0 MEASUREMENT AND PAYMENT

9.1 General

Except otherwise specified herein or elsewhere in the Contract Documents, no measurement and payment will be made for the under mentioned items related to this section. The cost thereof shall be deemed to have been included in the quoted unit rates of the items of the Bill of Quantities under this section.

9.1.1 Timber shoring, planking, strutting and providing slope for upholding the sides of excavations.

- 9.1.2 Benching of sufficient width for slope stability and movement of equipment and machinery.
- 9.1.3 De-watering where required to keep the excavated areas dry for pavements, structures, storm water drains and culverts, during construction.
- 9.1.4 Rolling, leveling, watering and compaction for construction of embankments to required density.
- 9.1.5 Any fill with approved materials necessitated by over excavation due to fault or convenience of the Contractor.
- 9.1.6 Stock piling the excavated materials at approved location within Contract limits and transporting back suitable material to places requiring fill or backfill.
- 9.1.7 Scarifying & compaction of ground.
- 9.1.8 Transporting & backfill the suitable material from stripping.
- 9.1.9 Extra excavation involved in providing adequate working space around sides of foundations and culverts.
- 9.1.10 Rolling, leveling, watering and compacting the fill and backfill to required density.
- 9.1.11 All laboratory and field tests stipulated in these specifications
- 9.1.12 Preparation of sub-grade

9.2 **Embankment (Select)**

9.2.1. Measurement

Measurement of acceptably completed work of constructing select embankment will be made on basis of actual volume in cubic metre / cubic feet of compacted select embankment placed in position in accordance with the lines, levels and grade as shown on drawings or as directed by the Engineer.

9.2.2 Payment

Payment will be made for acceptable measured quantity of select embankment on the basis of unit rate per cubic metre / cubic feet quoted in the relevant items of Bills of Quantities and shall constitute full compensation for all the work related to the item.

9.3 **Embankment (Common)**

9.3.1 Measurement

Measurement of acceptably completed work of constructing common embankment will be made on basis of actual volume in cubic metre / cubic feet of compacted embankment placed in position in accordance with the lines, levels and grade as shown on drawings or as directed by the Engineer.

9.3.2 Payment

Payment will be made for acceptable measured quantity of common embankment on the basis of unit rate per cubic metre / cubic feet quoted in the relevant items of Bills of Quantities and shall constitute full compensation for all the work related to the item.

9.4 **Excavation**

9.4.1 Measurement

The quantities set out for excavation and its subsequent disposal shall be deemed to be the bulk quantity before excavating and no allowance shall be made for any subsequent variations in bulk or for any extra excavation.

Measurement of acceptably completed works of excavation for structures, storm water drains and culverts will be made on the basis of actual volume in cubic metre / cubic foot of earth material excavated to the line, level and grade as shown on the drawings or as directed by the Engineer. It shall be calculated / measured from pre-work levels and levels shown on the drawing.

9.4.2 Payment

Payment will be made for acceptable measured quantity of excavation on the basis of unit rate per cubic metre / cubic foot quoted in the Bills of Quantities and shall constitute full compensation for all the work related to this item.

9.5 **Backfill/Fill**

9.5.1 Measurement

Measurement of acceptably completed works of backfill/fills for structures, storm water drains and culverts will be made on the basis of actual volume in cubic metre / cubic foot of compacted backfill/fill provided and placed in position in accordance with the lines, levels and grade as shown on the drawings or as directed by the Engineer.

9.5.2 Payment

Payment will be made for acceptable measured quantities of backfill/fills for structures, storm water drains and culverts on the basis of unit rate per cubic metre / cubic foot quoted in the respective items of Bills of Quantities and shall constitute full compensation for all the works related to the item.

*** End of Section 1100 ***

SECTION - 2100

FORMWORK

1. **SCOPE**
2. **GENERAL**
3. **MATERIALS**
4. **DELIVERY AND STORAGE**
5. **WORKMANSHIP**
6. **MEASUREMENT & PAYMENT**

SECTION - 2100

FORMWORK

1.0 SCOPE

The work under this section of the Specifications consists of furnishing all plant, labour, equipment, appliances and materials and in performing all operations in connection with the supply and installation of formwork for the purpose of containing concrete during placement and consolidation in the required shape and form.

2.0 GENERAL

It shall be the responsibility of the Contractor to perform the work by engaging well trained and experienced staff.

3.0 MATERIALS

The Contractor shall use the following materials for different purposes as stated below:

3.1 Timber

Form framing, sheathing and shoring.

3.2 Plywood

Form sheathing and panels.

3.3 Steel

- Heavy forms and false work
- Column and joint forms
- Permanent forms
- Welding of permanent forms

3.4 Form Ties Anchors and Hangers

For securing formwork against placing loads and pressures.

3.5 Coatings

Facilitate form removal.

3.6 Steel Joints

For formwork support.

3.7 Steel frame shoring

For formwork support.

4.0 DELIVERY AND STORAGE

4.1 Delivery

The delivery of formwork components shall be made in a manner so as not to cause damage.

4.2 **Storage**

Form work should be stored, after cleaning and preparing for re-use, if used before in such a manner that access to all different component is available.

Form work component which can be affected by weathering shall be stored in appropriate building or under covers and shade.

5.0 **WORKMANSHIP**

- 5.1 Forms shall have sufficient strength to withstand the pressure resulting from placement and vibration of the concrete and shall have sufficient rigidity to maintain specified tolerances.

Where required details and locations of special forms to be used are set out on the drawings. The Engineer shall reject any formwork in any part of the work which has been constructed with a non- approved formwork. Approval of form work by the Engineer shall be one of these conditions to be fulfilled before concreting. The Engineer shall reject any concreting which may not conform to the approved model.

- 5.2 Earth cuts shall not be used as forms for vertical surfaces of reinforced concrete work unless required as such or permitted by the Engineer.

- 5.3 Formwork shall be of timber, steel, plywood, proprietary building boards and such special materials, as may be approved by the Engineer, which give the required finish and shape to the surface of concrete. Wooden formwork shall be free from loose knots and shall be well seasoned.

- 5.4 The formwork shall conform to the shape, lines and dimensions as shown on the plans, and be so constructed as to remain sufficiently rigid during the placing and compacting of the concrete, and shall be sufficiently tight to prevent loss of liquid from the concrete.

The design and engineering of the formwork, as well as its construction, shall be the responsibility of the Contractor. Where necessary, to maintain the specified tolerances, the formwork shall be cambered to compensate for anticipated deflections in the formwork due to the weight and pressure of the fresh concrete and due to construction loads.

The Contractor shall establish and maintain in an undisturbed condition and until final completion and acceptance of the project, sufficient control points and bench marks to be used as references for checking upon tolerances.

- 5.5 Requirements for 'facing materials' are given in the Section relevant to 'Finishing of Formed Surfaces.'

- 5.6 Where natural plywood-form-finish, grout-cleaned-finish, smooth-rubbed-finish, scrubbed-finish, or sand-floated-finish is required, forms shall be smooth (faced with plywood, liner sheets, or prefabricated panels) and true to line, in order that the surfaces produced will require little dressing to arrive at true surfaces. Where any as-cast finish is required, no dressing shall be permitted in the finishing operation.

- 5.7 Where as-cast surfaces, including natural plywood- form-finish are specified, the panels of material against which concrete is cast shall be orderly in arrangement, with joints between panels planned in approved relation to openings, building corners, and other architectural features.

- 5.8 Where panels for as-cast surfaces are separated by recessed or otherwise emphasized joints, the structural design of the forms shall provide for locating form ties, where possible, within the joints so that patches of tie holes will not fall within the panel areas.

- 5.9 Forms shall not be re-used if there is any evidence of surface wear and tear or defect which would impair the quality of the surface finish. Forms shall be thoroughly cleaned and properly coated before re-use.
- 5.10 Forms shall be sufficiently tight to prevent loss of mortar from the concrete. Unless otherwise specified in the Contract documents chamfer strips shall be placed in the corners of forms to produce beveled edges on permanently exposed surfaces. Interior corners on such surfaces and the edges of formed joints will not require beveling unless required by the Contract documents.
- 5.11 Positive means such as wedges or jacks for accurate adjustment and for proper removal of shores and struts shall be provided and all settlement shall be monitored during concrete placing operation. Forms shall be securely braced against lateral deflections.
- 5.12 Where concreting of thin members is required to be carried out within formwork of considerable depth, temporary openings in the sides of the formwork shall be provided where necessary to facilitate the placing and consolidation of concrete. Small temporary openings shall also be provided at the bottom of the formwork for columns, walls and deep beams to permit the cleaning out of debris and observation immediately before concrete is deposited.
- 5.13 Form ties shall be constructed so that the ends or end fasteners can be removed without causing appreciable spalling at the faces of the concrete. After the ends or end fasteners of form ties have been removed, the embedded portion of the ties shall terminate not less than twice the diameter or twice the minimum dimension of the tie from the formed faces of concrete to be permanently exposed to view and in no case shall this distance be less than 19mm (3/4 in.) when the formed face of the concrete is not to be permanently exposed to view from ties may be cut off flush with the formed surfaces.
- Through bolts may be permitted provided that they are greased to allow for easy withdrawal and the holes subsequently made good. Through bolts are not to be used on water-retaining structures.
- 5.14 At construction joints contact surface of the form sheathing for flush surfaces exposed to view shall overlap the hardened concrete in the previous placement by no less than 25mm (1 in.). The forms shall be held against the hardened concrete to prevent offsets or loss of mortar at the construction joint so as to maintain a true surface.
- 5.15 Wood forms for wall opening shall be constructed to facilitate loosening, if necessary, to counteract swelling of the forms.
- 5.16 Wedges used for final adjustment of the forms prior to concrete placement shall be fastened in position after the final check.
- 5.17 Formwork shall be so anchored to shores or to other supporting surfaces or members that upward or lateral movement of any part of the formwork system during concrete placement will not occur.
- 5.18 Runways or planks for moving labour and equipment shall be provided with struts or legs and shall be supported directly on the formwork or upon the structural member without resting on the reinforcing steel.
- 5.19 All surfaces of forms and embedded materials shall be cleaned of any accumulated mortar or grout from previous concreting and of all other foreign material before placing fresh concrete.
- 5.20 Forms shall be sufficiently tight to prevent leakage of grout or cement paste. Board forms having joints opened by shrinkage of the wood shall be removed and replaced. Plywood and other wood surfaces not subject to shrinkage shall be sealed against

absorption of moisture from the concrete by either (1) a field applied, approved form oil or sealer, or (2) a factory applied non-absorptive liner. When forms are coated to prevent bond with concrete, it shall be done prior to placing of the reinforcing steel. Excess coating material shall not be allowed to stand in puddles in the forms nor allowed to come in contact with the concrete against which fresh concrete will be placed. Care shall be taken that such approved composition is kept out of contact with the reinforcement. Where as-cast finishes are required, materials, which will impart a stain to the concrete, shall not be applied to the form surfaces. Where the finished surface is required to be painted, the material applied to form surfaces shall be compatible with the type of paint to be used.

- 5.21 For reinforced concrete, in no circumstances shall forms be struck until the concrete attains a strength of at least twice the stress to which the concrete may be exposed at the time of striking.

The strength referred to shall be that of concrete using the same cement and aggregates, with the same proportions, and cured under conditions of temperature and moisture similar to those obtaining in the work. Where possible, the formwork should be left for longer time as it would assist the curing.

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

- Walls, columns and vertical 48 hours or as may sides of beams decided by the Engineer.
- Side of slab (shores of 6 days props left under)
- Beams soffits (shores or 12 days props left under)
- Removal of shores or props to slabs:
 1. Spanning upto 4 metre (13 ft.) 10 days.
 2. Spanning over 4 metre (13 ft.) 16 days.
- Removal of shores or props to beams:
 1. Spanning upto 6 metre (20 ft.) 18 days.
 2. Spanning over 6 metre (20 ft.) 25 days.

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

The number of shores or props, their sizes and disposition shall be such as to be able to safely carry the full dead load of the slab and beams, as the case may be.

Proper allowance shall be made for the decrease in rate of hardening of concrete in cold weather and the above minimum duration must be increased when the mean daily temperature is below 20° C.

- 5.22 When repair of surface defects or finishing is required at an early age, forms shall be removed as soon as the concrete has hardened sufficiently to resist damage from removal operations.

- 5.23 Top forms on sloping surfaces of concrete shall be removed as soon as the concrete has attained sufficient stiffness to prevent sagging. Any needed repairs or treatment required on such sloping surfaces shall be performed at once and be followed by the specified curing.

- 5.24 Wood forms for wall openings shall be loosened as soon as this can be accomplished without damage to the concrete.
- 5.25 All formwork shall be removed without such shock or vibration as would damage the reinforced concrete. Before the top plank and struts are removed, the concrete surface shall be exposed where necessary in order to ascertain that the concrete has sufficiently hardened. Proper precautions shall be taken to allow for the decrease in the rate of hardening that occurs with all cement in the cold weather.
- 5.26 When reshoring or repropping is permitted or required, the operations shall be planned in advance and shall be subject to approval. While reshoring is underway no live loads shall be permitted on the new construction.

In no case during reshoring shall concrete in beams, slab, columns or any other structural member be subjected to combined dead and construction loads in excess of the load permitted by the Engineer for the developed concrete strength at the time of reshoring.

Reshores shall be placed as soon as practicable after stripping operations are complete but in no case later than the end of working day on which stripping occurs.

Reshores shall be tightened to carry their required loads without overstressing the construction. Reshores shall remain in place at least until tests representative of the concrete being supported have reached the strength specified in sub-clause 5.23 hereof.

- 5.27 Floors supporting props or shores under newly placed concrete shall have their original supporting props or shores left in place or shall be reshored. The reshoring system shall have a capacity sufficient to resist the anticipated loads and in all cases shall have a capacity equal to at least one half the capacity of the shoring system above. The reshores shall be located directly under a shore position above unless other locations are permitted.

The reshoring or re-propping shall extend over a sufficient number of storeys to distribute the weight of newly placed concrete, forms, and construction live loads in such a manner that the design superimposed loads of the floors supporting shores or props are not exceeded.

- 5.28 It is generally desirable to give forms for reinforced concrete an upward camber to ensure that the beams or slabs (specially cantilever slabs) do not have a sag when they have taken up their deflection, but this should not be done unless permitted by the Engineer.
- 5.29 No loads, other than man and light plant required in connection with the actual work in hand, shall be allowed on suspended floors until 28 days after concreting where ordinary Portland Cement is used and 14 days when rapid hardening Portland Cement is used.
- 5.30 Prior to placing concrete, all forms shall be inspected and all debris and extraneous matter removed. The form oil or release agent shall not react with concrete to affect the strength nor shall it give any colour. It shall be applied in such a manner as not to contaminate the reinforcement and other fixtures to be embedded in concrete.
- 5.31 Formwork for concrete pavement shall be made of steel of an approved section, with a base width of at least 200 millimeters (8 in.) and the depth shall be equal to the thickness of the pavement at the edge as shown on the plans. The forms shall be staked with steel stakes, and stakes shall be of a length approved by the Engineer. Each section of forms shall have a stake pocket at each end and at intervals of not more than 1.5 meters (5 ft.) between ends. The stake pockets shall have approved devices for locking the form to the steel stakes. Each section of forms shall be straight and free from bends and warps at all times. No section shall show a variation greater than 3 millimeter in 3 meters (1/8 inch in

10 ft.) from a true plane surface on the top of the form, and the inside face shall not vary more than 6 millimeters (1/4 in.) from a plane surface.

Before placing forms, the underlying base shall be to the required grade, and shall be firm and compact. The forms shall have full bearing upon the foundation throughout their length and shall be placed with exactness to the required grade and alignment of the edge of the finished pavement. They shall be so supported during the entire operation of placing, tamping and finishing the pavement that they will not deviate vertically at any time more than 3 millimeters (1/8 in.) from the proper elevation.

Forms shall not be removed for at least twelve (12) hours after the concrete has been placed. Forms shall be carefully removed in a manner to avoid damage to the pavement. Under no circumstances will the use of pry bars between the forms and the pavement be permitted. Pavement, which in the opinion of the Engineer, is damaged due to the careless removal of forms shall be repaired by the Contractor, as directed by the Engineer, at the Contractor's own expense. Forms shall be thoroughly cleaned and oiled each time they are used.

When pavement is placed adjoining existing concrete pavement upon which the finishing machine will travel, any irregularities in the old pavement shall be ground down to a true, uniform surface, of sufficient width to accommodate the wheels of the finishing equipment, if necessary to obtain proper smoothness of the pavement.

6.0 MEASUREMENT AND PAYMENT

Except otherwise specified in the Bill of Quantities no payment will be made for the works involved within the scope of this section of the specifications.

The cost thereof shall be deemed to have been included in the quoted unit rate of relevant concrete items of the Bills of Quantities.

*** End of Section 2100 ***

SECTION - 2200
REINFORCEMENT

- 1. SCOPE**
- 2. APPLICABLE STANDARDS**
- 3. MATERIALS**
- 4. COMPLIANCE WITH SPECIFICATIONS**
- 5. DELIVERY & STORAGE**
- 6. BAR BENDING SCHEDULES**
- 7. FABRICATING, BENDING AND PLACING**
- 8. MEASUREMENT & PAYMENT**

SECTION - 2200
REINFORCEMENT

1.0 SCOPE

The work under this section of specification consists of furnishing all plant, labour, equipment, appliances and materials and performing all operations in connection with the supply, transporting, cutting, bending and placing steel reinforcement, welded wire-fabric, dowels, tie-bars and assemblies in concrete structures, pavement or elsewhere, at any floor and at any height as shown in the drawings, as specified herein and as required by the site conditions or as directed by the Engineer.

2.0 APPLICABLE STANDARDS

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

Pakistan Standard

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

British Standard

B.S 4449	Carbon steel bars for reinforcement of concrete
B.S 4466	Specifications for Bending dimensions and scheduling of bars for the reinforcement of concrete.

ASTM Standard

A 185	Standard specification for welded steel wire fabric for concrete reinforcement.
A 305	Minimum requirement for the deformations of deformed steel bars for concrete reinforcement.
A 615	Standard specification for deformed and plain billet steel bars for concrete reinforcement.

ACI Codes

ACI 315	Details and Detailing of Concrete Reinforcement (ACI Publication SP-66)
ACI 318	Building Code Requirements for Reinforced Concrete.

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

3.0 **MATERIALS**

3.1 **Reinforcement**

3.1.1 General

Reinforcement shall be obtained only from manufacturers approved by the Engineer. Each consignment of reinforcement steel shall be accompanied by the manufacturer's certificate or shall refer to a previous certificate, if the consignment is from the same batch, showing that the reinforcement steel complies with the specified requirement. If such certificate is not made available, the Engineer may direct testing of different consignments of reinforcing steel at the Contractor's cost. Should the result of such tests show that the sample does not meet with the specifications the whole consignment shall be rejected and removed from the site at the Contractor's cost.

Reinforcement shall be free from all loose or flaky rust and mill scale or coating, and any other substance that would reduce or destroy the bond. Reduced section steel reinforcement shall not be used.

3.1.2 Reinforcing Steel

Unless otherwise specified, all plain reinforcing bars shall comply with the requirements of B.S 4449 for plain mild steel bars and shall have a minimum characteristic strength of 36,000 psi (250 MPa).

Unless otherwise specified, all deformed reinforcing bars shall comply with the requirements of ASTM A-615 for deformed hot rolled new stock billet steel bars and shall have a minimum characteristic strength of 40,000 psi (276 Mpa) and 60,000 psi (414 MPa), as shown on drawings.

3.1.3 Spacers and Supports

Spacers and supports shall be approved standard products of types best suited for the purpose.

3.1.4 Welding

The bars shall not be welded, unless prior approval of the Engineer is obtained in writing. If permitted, welding shall be done in accordance with relevant codes and standards taking all necessary precautions and safeguards. Where welding is unavoidable the Engineer may require substitution of the high strength deformed bars by plain round steel bars of lower grade, conforming to BS 4449, of equivalent strength.

4.0 **COMPLIANCE WITH SPECIFICATIONS**

The Contractor shall submit certificates of compliance from the manufacturer stating that the supplied reinforcement conforms to the Specifications. In addition, wherever and as directed by the Engineer, conformance of the supplied reinforcing bars with the specifications shall be demonstrated by the Contractor through laboratory tests, in accordance with the relevant standards.

5.0 DELIVERY & STORAGE

5.1 Delivery

Steel reinforcement bars shall be kept in bundles firmly secured and tagged. Each bar or bundle of bars shall be identified by marks as per relevant BS standard.

5.2 Storage

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

6.0 BAR BENDING SCHEDULES

The Contractor shall prepare bar bending schedules of all the reinforcing steel bars and shall obtain approval of the Engineer before proceeding with the work.

The Engineer's approval, however, will not relieve the Contractor of his responsibility in this regard.

7.0 FABRICATING, BENDING & PLACING

7.1 Reinforcement shall be accurately placed as shown in drawings and secured against displacement by using 16 gauge steel wire ties or suitable clips at intersections and supported from the formwork by using concrete, metal or plastic chains, spacers or hangers of an approved pattern. Where concrete blocks are used for ensuring the cover, they shall be made of mortar not leaner than one part of cement to two parts of sand.

Where the concrete surface will be exposed to the weather in the finished structure, the portions of all accessories in contact with the form work shall be galvanized or shall be made of plastic.

7.2 Bars used for concrete reinforcement shall be fabricated in accordance with the dimensions shown in the bar bending schedule approved by the Engineer.

7.3 The cutting tolerance for all reinforcing bars shall be 19 mm (3/4 in.).

7.4 Fabricating tolerance shall be as per ACI - 315.

7.5 Placing tolerances shall be as per ACI-318 & 317.

7.6 Bars may be moved as necessary to avoid interference with other reinforcing steel, conduits, or embedded items. If bars are moved more than one bar diameter or enough to exceed the above tolerances, the resulting arrangement of bars shall be subject to approval of Engineer.

7.7 Vertical bars in columns shall be offset at least one bar diameter at lapped splices. To ensure proper placement, templates shall be furnished for all columns dowels.

7.8 Reinforcement shall not be bent or straightened in a manner that will injure the material.

No bars shall be bent twice in the same place, nor shall they be straightened after bending.

Unless permitted, by Engineer, reinforcement shall not be bent after being partially embedded in hardened concrete.

- 7.9 No splice of reinforcement shall be made except as approved by the Engineer.
- 7.10 Welding of reinforcement shall not be done unless permitted and approved by the Engineer.
- 7.11 Exposed reinforcement intended for bonding with future extensions is to be effectively protected from corrosion. Protection is also to be provided to reinforcement partly built into concrete where the exposed part is to be built into later concrete.
- 7.12 No concreting is to be carried out until the reinforcement has been checked and approved by the Engineer.
- 7.13 All detailing shall be done as per ACI standards ACI-315, ACI-318 & ACI-350R, as and where required.
- 7.14 Standard or actual unit weight whichever is lesser shall be used for calculation of weights.

8.0 **MEASUREMENT & PAYMENT**

8.1 **General**

Except otherwise specified herein or elsewhere in the Contract Documents no measurement and payment will be made for the under mentioned specified works related to the relevant items of the Bills of Quantities. The cost thereof shall be deemed to have been included in the quoted unit rate of the respective items of the Bills of Quantities.

- 8.1.1 Providing and installing chairs, supports, hooks, spacers, binding wires, corrosion protection sleeves, wire cage or basket for tie bars and dowels and laps not shown on drawings including wastage and rolling margin.
- 8.1.2 Testing of mild steel, deformed steel, welded wire fabric, dowels, tie bars and assemblies.

8.2 **Reinforcing Bars.**

8.2.1 Measurement

Measurement for acceptably completed works of reinforcement shall be made by weight in metric ton according to bar bending schedules approved by the Engineer.

8.2.2 Payment

Payment will be made for acceptable measured quantity of reinforcement provided and placed in position on the basis of unit rate per metric ton quoted in the Bill of Quantities and shall constitute full compensation for all the works related to the item.

*** End of Section 2200 ***

SECTION – 2300

PLAIN AND REINFORCED CONCRETE

- 1. SCOPE**
- 2. GENERAL**
- 3. APPLICABLE STANDARDS**
- 4. MATERIALS**
- 5. NOMINAL CONCRETE MIXES**
- 6. TEST OF CONCRETE QUALITY**
- 7. FINISHING OF FORMED SURFACES**
- 8. REPAIR OF SURFACE DEFECTS**
- 9. CONCRETE CONSTRUCTION TOLERANCES**
- 10. ACCEPTANCE OF STRUCTURE**
- 11. PVC WATER STOP/HYDROFOIL**
- 12. NON SHRINK GROUT**
- 13. VAPOUR BARRIER**
- 14. MEASUREMENT AND PAYMENT**

SECTION 2300

PLAIN AND REINFORCED CONCRETE

1. SCOPE

The work under this section of the specification consists of furnishing all plant, labour, equipment, appliances and materials and in performing all operations in connection with the supply and installation of plain and reinforced concrete work complete in any floor and at any height as per drawings except where specifically stated in the relevant item of Bill of Quantities, in strict accordance with this section of the specifications and the applicable drawings, and subject to the terms and conditions of the Contract. The scope of this section of specification is covered with detailed specifications as laid down herein.

2. GENERAL

- 2.1 Full co-operation shall be given to trades like electrical, mechanical and other services.
- 2.2 Suitable templates or instructions or both shall be provided for setting out items not placed in the forms. Embedded items and other materials for mechanical and electrical operations shall have been completed, inspected, tested and approved before concrete is placed.
- 2.3 For special concrete finish and for special methods of construction (e.g. slip forms), formwork shop drawings shall be designed and prepared by the Contractor, at his own cost. Approval of shop drawings as well as that of actual samples of concrete finish shall be obtained before work is commenced.

3. APPLICABLE STANDARDS

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

3.1 Pakistan Standards

PS 177	Compaction factor test.
PS 232	Portland Cement (ordinary & rapid hardening).
PS 243	Natural aggregates for concrete.
PS 279	Abrasion of coarse aggregates by the use of Los Angeles machine.
PS 280	Determination of aggregates crushing value.
PS 281	Organic impurities in sand for concrete aggregates.
PS 282	Material finer than No. 200 B.S. test sieve in aggregates, method of test for.
PS 283	Soundness test for aggregates by the use of sodium sulphate or magnesium sulphate.
PS 284	Sampling aggregates for concrete.
PS 285	Sieve or screen analysis of fine and coarse aggregates.
PS 286	Description and classification of mineral aggregates.
PS 421	Sampling fresh concrete.
PS 422	Slump test for concrete.
PS 560	Making and curing concrete compression test specimen in the field.
PS 612	Sulphate-resistant Portland cement type 'A' and sampling fresh concrete in the laboratory.
PS 716	Mixing and sampling fresh concrete in the laboratory.
PS 717	Compacting factor test for concrete.
PS 746	Definitions and terminology of cements.
PS 849	Making and curing concrete compression test cubes.

3.2 ASTM (American Society for Testing and Materials)

B 370	Copper sheet and strip for building construction.
C 33	Concrete Aggregates.

C	40	Organic impurities in sand for concrete.
C	87	Effect of organic impurities in fine aggregates on of mortar.
C	88	Soundness of aggregates.
C	94	Ready mixed Concrete.
C	109	Compressive strength of hydraulic cement mortars.
C	117	Material finer than No.200 (0.075mm) sieve.
C	123	Light-weight pieces in aggregates.
C	125	Concrete and concrete aggregates.
C	127	Specific gravity and absorption of coarse aggregate.
C	128	Specific gravity and absorption of fine aggregate.
C	131	Resistance to abrasion of small size coarse aggregates.
C	136	Sieve or screen analysis of fine and coarse aggregate.
C	142	Clay lumps and friable particles in aggregates.
C	143	Slump of Portland Cement Concrete.
C	144	Aggregate for masonry mortar.
C	150	Portland Cement.
C	156	Water retention by concrete curing material
C	171	Sheet material for curing concrete.
C	185	Air content or hydraulic cement mortar.
C	188	Density of hydraulic cement.
C	191	Time of setting of hydraulic cement by vicat needle.
C	260	Air entraining admixtures for concrete.
C	289	Potential reactivity of aggregate.
C	309	Liquid membrane-forming compounds for curing concrete.
C	330	Lightweight aggregates for structural concrete.
C	331	Lightweight aggregates for concrete masonry.
C	332	Lightweight aggregates for insulating concrete.
C	494	Chemical admixtures for concrete.
C	535	Resistance to abrasion of large size coarse aggregates.
C	567	Unit weight of structural lightweight concrete.
D	75	Aggregate sampling.
D	994	Preformed expansion joint filler for concrete.
D	1190	Concrete joint sealer (hot poured elastic type).
D	1751	Preformed expansion joint filler for concrete paving and structural construction.
D	1752	Preformed sponge rubber and cork expansion joint fillers for concrete paving and structural construction.
D	1850	Concrete joint sealer (cold application type).
E	11	Wire cloth sleeves for testing purposes.
E	96	Water vapour transmission of materials in sheet form.
E	154	Materials for use as vapour barrier under concrete slabs.
E	337	Relative humidity by wet and dry bulk psychrometer.

3.3 ACI (American Concrete Institute)

211.1	Recommended practice for selecting proportions for normal and heavy weight concrete.
214	Recommended practice for evaluation of strength test result of concrete
301	Specifications for structural concrete for buildings.
304	Recommended practice for measuring, mixing, transporting and placing concrete.
305	Hot weather concreting.
308	Recommended practice for curing concrete.
309	Recommended practice for consolidation of concrete.
318	Building code requirements for reinforced concrete.
347	Recommended practice for concrete formwork.
512	Precast structural concrete in building.
517	Low pressure steam curing.
533	Fabrication, handling and erection of Precast concrete wall panels.

3.4 British Standards

BS 12	Portland cement, ordinary and rapid hardening.
BS 410	Test Sieves.
BS 812	Methods for the sampling and testing of mineral aggregates, sands and fillers.
BS 882	Coarse and fine aggregates from natural sources.
BS 1305	Batch Mixer.
BS 1881	Methods of testing and sampling concrete.
BS 3148	Tests for water for making concrete.
BS 3837	Expanded polystyrene boards.
BS 5328	Structural Concrete.,
BS 3869	Rigid expanded polyvinyl chloride for thermal insulation.
BS 3927	Phenolic foam materials for thermal insulation and building applications.
BS 4027	Sulphate-resisting Portland cement.
BS 8110	Structural use of concrete.
CP 114	Structural use of reinforced concrete in buildings.
CP 116	Structural use of Precast concrete.
CP 5337	The structural use of concrete for retaining aqueous liquids.

In addition, the latest editions of other Pakistan and British Standards, American Concrete Institute Standards, American Society for Testing and Materials Standards and other Standards as may be specified by the Engineer for special Materials and Construction are also relevant.

4. MATERIALS

4.1 Aggregates

- 4.1.1 The sources of supply of all fine and coarse aggregates shall be subject to the approval of the Engineer.
- 4.1.2 All fine and coarse aggregates shall be clean and free from clay, loam, silt and other deleterious matter. If required, the Engineer reserves the right to have them washed by the Contractor at no additional expense. Coarse and fine aggregates shall be delivered and stored separately at site. Aggregates shall not be stored on muddy ground or where they are likely to become dirty or contaminated.
- 4.1.3 Fine aggregate shall be hard coarse sand, crushed stone or gravel screenings and shall conform to requirements of PS 243 and/or BS 882 and/or ASTM C 33. Only fine aggregate of grading zones 1 to 3 (BS 882) shall be used.
- 4.1.4 Coarse aggregate shall be gravel or crush stone of hard, durable material free from laminated structure and conforming to PS 243 and/or BS 882 and/or ASTM C 33 graded as follows for use in mass concrete as in foundations:

<u>Total Passing B.S. Sieve</u>	<u>Percent by weight</u>
3 in. (76.20 mm) :	100
1.5 in. (38.10 mm) :	95-100
0.75 in. (19.05 mm) :	30-70
0.38 in. (9.52 mm) :	10-35
0.19 in. (4.76 mm) :	0-5

Coarse aggregate for all cast-in-place concrete other than mass concrete as for foundations shall be graded with the following limits:

Total Passing B.S. Sieve			Percent by weight
.5 in.	(38.10 mm)	:	100
0.75 in.	(19.05 mm)	:	95-100
0.38 in.	(9.52 mm)	:	25-55
0.19 in	(4.76 mm)	:	0-10

4.1.5 Wherever feasible, the nominal maximum size of aggregate for cast- in- place reinforced concrete slabs and other members, shall be 3/4 inch. If there are difficulties in placing such a concrete the maximum size may be restricted to 1/2 inch provided the requirements for strength are satisfied. The grading requirements of 1/2 inch or 3/8 inch down aggregate shall be agreed to with the Engineer as per relevant ASTM/BS standards.

4.1.6 The nominal maximum size of the aggregate for Precast concrete shall not be larger than one fifth of the narrowest dimension between sides of forms, or one-third of the depth of slabs or three-fourths of the minimum clear distance between reinforcing bars or between bars and forms, whichever is least. In Precast columns the nominal maximum size of the aggregate shall be limited as above but shall not be larger than two-thirds of the minimum clear distance between bars.

4.1.7 Coarse aggregates in Precast concrete of normal weight may be of one maximum size for all concrete placed in 1 day when quantities to be placed are too small to permit economical use of more than one mix design.

When a single mix design is so used, the maximum nominal size shall be as required for the most critical condition of concreting, in accordance with the requirements of clause (4.1.6) above.

4.1.8 Except where it can be shown to the satisfaction of the Engineer that a supply of properly graded aggregate of uniform quality can be maintained over the period of the work, the grading of the aggregates shall be controlled by obtaining the 3/4" maximum nominal size, the different sizes being stocked in separate stock piles and recombined in the correct proportion for each batch at the batching plant. The materials shall be stock-piled for a period before use so as to drain nearly to constant moisture content (as long as site and other conditions permit, preferably for at least a day). The grading of the coarse and fine aggregates shall be tested at least once for every 100 tons supplied, to ensure that the grading is uniform and same as that of the samples used in the preliminary tests.

4.1.9 For use in fire proof concrete, the aggregates shall be fire clay and semi-acidic fine ground. The use of broken fire clay bricks as coarse aggregate and waste of semi-acidic refractory particles as fine aggregate can be allowed.

4.2 Cement

4.2.1 The cement shall be fresh and of approved origin and manufacture. It shall be one of the following as may be specified by the Engineer.

- Ordinary or Rapid Hardening Portland cements complying with the requirements of PS 232 or BS 12 or ASTM C 150.
- Sulphate Resisting Portland/Cement complying with the requirements of PS 612 or BS 4027 or ASTM C 150.

4.2.2 Unless otherwise specified, ordinary Portland cement complying with the requirements of BS 12 shall be used.

- 4.2.3 For all fair faced concrete it will be necessary to use approved cement with a view to obtain a light shade concrete as approved by the Engineer.
- 4.2.4 The Contractor shall supply to the Engineer at fortnightly intervals, test certificates with the appropriate standard in respect of the samples of cement from the work-site. These tests shall be carried out in a laboratory approved by the Engineer.
- 4.2.5 Only one brand of each type of cement shall be used for concrete in any individual member of the structure. Cement shall be used in the sequence of receipt of shipment, unless otherwise directed.
- 4.2.6 There shall be sufficient cement at site to ensure that each section of work is completed without interruption.
- 4.2.7 Cement reclaimed from cleaning of bags or from leaky containers shall not be used.
- 4.2.8 The Contractor shall provide and erect (at his cost) a suitable plain, dry, well ventilated, weather-proof and water proof shed of sufficient capacity to store the cement.
- 4.2.9 Cement shall be used as soon as possible after delivery and cement which the Engineer considers has become stale or unsuitable through absorption of moisture from the atmosphere or otherwise shall be rejected and removed immediately from the site at the Contractor's expense. Any cement in containers damaged so as to allow the contents to spill or permitting access of the atmosphere prior to opening of the container at the time of concrete mixing shall be rejected and removed immediately from the site at the Contractor's expense.
- 4.2.10 The mixing together of different types of cement will not be permitted.

4.3 Water

Only clean water from the city supply, tube well installed at the site or from other sources approved by the Engineer shall be used. The Contractor shall supply sufficient water for all purposes, including mixing the concrete, curing and cleaning plant and tools. Where doubt exists as to the suitability of the water, it shall be tested in accordance with BS 3148. Where water can be shown to contain any sugar or an excess of acid, alkali or salt, the Engineer may refuse to permit its use.

In case of doubt, the Engineer may require that concrete mixed with water proposed to be used should not have a compressive strength lower than 90 percent of the strength of concrete mixed with distilled water.

4.4 Additive

All additives such as foaming and water proofing agents shall be from a manufacturer approved by the Engineer.

Air Entraining Admixtures shall conform to ASTM C 260. Other Admixtures shall conform to ASTM C 494.

5. **NOMINAL CONCRETE MIXES**

5.1 Proportions of Mix

5.1.1 Cement and aggregates:

Cement, fine aggregate and the coarse aggregate shall be weighed separately. The proportions of cement to fine aggregate and coarse aggregate shall be

adjusted so as to provide the concrete of the required crushing strength when tested as set out in Table 1.

5.1.2 The Contractor shall regulate and arrange mixing of the ingredients for the designed mix of the concrete by weight-batching. The cost of designing the mix shall be borne by the Contractor.

5.1.3 Water/Cement ratio:

The quantity of water used shall be just sufficient to produce a dense concrete of adequate strength and workability for its purpose. For all external work and foundations the water/cement ratio should not exceed 0.55 for concrete Class A, B and C.

5.1.4 Workability:

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

'Workability' shall be determined by either the slump or compaction factor tests as directed by the Engineer and these shall be performed in accordance with the methods given in PS 422 to PS 177 or ASTM C 143.

The slump or compaction factor for each class of concrete shall be determined during the preliminary Test mixes and the value obtained shall not be modified without the written consent of the Engineer. Unless otherwise permitted or specified, the concrete shall be proportioned and produced to have a slump of 3 inch or less for consolidation by vibration. A tolerance of upto 1 inch above the indicated maximum shall be allowed for individual batches provided the average for all batches or the most recent 10 batches tested, which ever is fewer, does not exceed the maximum limit. Concrete of lower than usual slump may be used provided it is properly placed and consolidated.

5.2 Strength requirements for concrete

5.2.1 Portland cement concrete when aggregates comply with BS 882.

5.2.2 Concrete made with Portland cement shall comply with the strength requirements of Table 1, columns 4&6 (Works Test).

Table 1: Strength requirements for Portland concrete with aggregates complying with BS. 882.

Class of Concrete (kg)	Nominal Design Mix	Min Cement per Cu.ft of compacted concrete (lb.)	Cube strength at 28 days after mixing & pouring (psi)		Alternative Cube strength at 7 days after mixing & pouring (psi)		Maximum water consumption per 110 lb. bag of cement (gallon)
			Preliminary tests	Works tests	Preliminary tests	Works tests	
1	2	3	4	5	6	7	8
A	1:1:2	30.00	5800	4350	3875	2900	4.40
B	1:1-1/2:3	22.00	4900	3750	3300	2450	5.06
C	1:2:4	18.00	4000	3000	2700	2000	5.28
D	1:3:6	13.00	2000	1550	1350	1000	7.05
E	1:4:8	9.50	-----	1000	-----		7.27

**Note: Conversion Factors. 1 psi = 0.006897 MPa 1 gal = 4.54 liter
1 lb. = 0.4537 Kg.
1cu.ft. = 0.028 cum.**

- 5.2.3 The strengths given in Table 1 are based on the assumption that average temperature is 20 degree C. Where accurate records of temperature are kept, allowance may be made for change of temperature or the cubes may be tested at the equivalent maturity.
- 5.2.4 All structural concrete shall conform to BS 5328.
- 5.2.5 Unless otherwise stated, the types of concrete shall be classified on the basis of compressive strength requirements. The Contractor shall provide Mix design by weight for each class of concrete.

Manufacture 12 test cubes for each 3 mix design batches (6 x 6 x 6) inches in accordance with the Mix design batching by weight and test 3 cubes each at 3,7,14 & 28 days intervals in the presence of Engineer's Representative and submit all relevant data and results of tests for approval of the Engineer. The Contractor shall obtain approval from the Engineer in writing for each Mix design before producing the actual concrete for the Works.

No payments for producing the Mix design, manufacture of test cubes and testing shall be paid. The Contractor shall include this cost in the relevant item of concrete.

5.3 **Batching**

- 5.3.1 All cement, including cement supplied in bulk, shall be batched by weight. A bag of cement may be taken as weighing 110 lb. with the prior approval of the Engineer.
- 5.3.2 Aggregates shall be batched by weight, due allowance being made for water content. Aggregates may be batched by volume through conversion of weigh batching, only with the prior permission of the Engineer. The apparatus for weight-batching may be an integral part of the mixer or a separate unit of a type approved by the Engineer. It shall be accurate within 2% and shall be checked for accuracy at least once a week.
- 5.3.3 The quantity of additives i.e. foaming and water proofing agents etc. shall be as prescribed by the manufacturer or as directed by the Engineer.
- 5.3.4 Where the batching plant is of the type in which cement and aggregates are weighed in the same compartment, the cement shall be introduced into the compartment between two sizes of aggregates.
- 5.3.5 Each batch shall be so charged into the mixer that some water will enter in advance of the cement and aggregates. Water shall continue to flow for a period which may extend to the end of the first 25 percent of the specified mixing time. Controls shall be provided to prevent batched ingredients from entering the mixer before the previous batch has been completely discharged.

5.4 **Mixing**

- 5.4.1 The concrete shall be mixed in an approved batch mixer conforming to the requirements of BS 1305. It shall be fitted with the manufacturer's plate stating the rates, capacity and the recommended number of revolutions per minute and shall be operated in accordance therewith. It shall be equipped with a suitable charging mechanism and an accurate water measuring device. The mixer shall be capable of thoroughly combining the aggregates, cement and water into a uniform mass within the specified mixing time and of discharging the concrete without harmful segregation.

- 5.4.2 Mixing shall continue for the period recommended by the mixer manufacturer or until there is apparently a uniform distribution of the materials and the mass is uniform in colour, whichever period is longer. If it is desired to use a mixing period of less than 1-1/2 minutes, the Engineer's approval shall be obtained in writing.
- 5.4.3 Controls shall be provided to ensure that the batch cannot be discharged until the required mixing time has elapsed. At least three quarters of the required mixing time shall take place after the last of the mixing water has been added.
- 5.4.4 The interior of the mixer shall be free of accumulations that will interfere with mixing action. Mixing blades shall be replaced when they have lost 10 percent of their original height.
- 5.4.5 Concrete shall be mixed only in quantities for immediate use. Concrete which has set shall not be retempered, but shall be discarded.

5.5 **Transporting**

- 5.5.1 The concrete shall be transported from the place of mixing to the place of final deposit as rapidly as practicable by means which will prevent segregation or loss of ingredients. All skip vehicles, or containers used for transporting the concrete shall be thoroughly cleaned.
- 5.5.2 During hot or cold weather, concrete shall be transported in deep containers, on account of their lower ratios of surface area to mass, which reduces the rate of loss of water by evaporation during hot weather and loss of heat during cold weather.

5.6 **Placing**

- 5.6.1 Before placing of concrete, formwork shall have been completed; water shall have been removed; reinforcement shall have been secured in place; expansion joint material, anchors and other embedded items shall have been kept in position; and the entire preparation shall have been approved by the Engineer.

No concrete is to be placed into the foundation trenches until the ground to receive the same has been examined and approved by the Engineer for this purpose.

- 5.6.2 Concrete shall be deposited continuously, or in layers of such thickness that no concrete will be deposited on concrete which has hardened sufficiently to cause the formation of seams or planes of weakness within the section. If a section cannot be placed continuously, construction joints shall be located as shown in the Contract Documents or as approved by the Engineer. Placing shall be carried out at such a rate that the concrete which is being integrated with fresh concrete is still plastic. Concrete which has partially hardened shall not be deposited. Temporary spreaders in forms shall be removed when the concrete placing has reached an elevation rendering their services unnecessary. They may remain embedded in the concrete only if made of metal or concrete and if prior approval has been obtained.
- 5.6.3 The actual sequence of construction proposed by the Contractor shall be subject to the Engineer's approval before construction starts on any part of the structure, and this sequence shall not be varied without the Engineer's approval.
- 5.6.4 The concrete after it has been mixed shall be placed as soon as it is practicable. Once the concrete has left the mixer, no more water shall be added, although the concrete may be mixed or agitated to help maintain

workability. The concrete shall not be used if, through any cause, the workability of the mix at the time of placing is too low for it to be compacted fully and to an acceptable finish by whatever means available.

The time between mixing and placing should be reduced, if the mix is richer or the initial workability of the mix is lower than normal, or if a rapid hardening cement or an accelerator is used, or if the work is carried out at a high temperature or exposed to a drying atmosphere.

The Contractor shall ensure that the delay between mixing and placing including consolidation does not exceed 45 minutes under any circumstances. Any concrete which does not satisfy this requirement shall be rejected.

- 5.6.5 Concrete shall be deposited as nearly as possible in its final position to avoid segregation due to re-handling or flowing. In no circumstances may concrete be railed or made to flow along the forms by the use of vibrators.

Concreting shall be carried on as a continuous operation using methods which shall prevent segregation or loss of ingredients.

- 5.6.6 The free fall of concrete shall not be allowed to exceed 6 feet. Where it is necessary for the concrete to be lowered more than this depth, it is not to be dropped into its final position, but shall be placed through pipes fed by a hopper. When a pipe is used for placing concrete the lower end shall be kept inside or close to the freshly deposited concrete. The size of the pipe shall be not less than 9 inch in diameter.

- 5.6.7 'Mass-concrete' shall be placed in layers approximately 18 inch thick. Vibrator heads shall extend into the previously placed layer.

- 5.6.8 The workmen carrying concrete to the site, and all other workmen moving about on the reinforcement before the concrete is placed, shall move only along runways or planks placed for the purpose and no person shall be allowed to walk on the reinforcement itself.

- 5.6.9 Prior to the laying of concrete on load bearing masonry walls, bearing plates and at other points, as may be directed by the Engineer, the surface will be brought to a true, hard and smooth level surface using cement sand mortar in the ratio of 1 volume of cement to 3 volumes of sand. Two layers of building paper weighing .082 lb./ft² will then be laid flat to separate the concrete from the surface on which it is to be laid.

5.7 **Construction Joints**

- 5.7.1 Concreting shall be carried out continuously up to construction joints, the position and arrangement of which shall be predetermined by the Engineer.

- 5.7.2 Joints not shown on the drawings shall be so made and located as to least impair the strength of the structure and shall need prior approval of the Engineer. In general, they shall be located near the middle of the spans of slabs and beams unless a secondary beam intersects a main beam at this point, in which case the joint in the main beam shall be offset a distance equal to twice the width of the secondary beam. Joints in walls and columns shall be at the underside of floors, slabs or beams and at the top of footings or floor slabs. Beams, brackets, columns capitals, haunches and drop panels shall be placed at the same time as slabs. Joints shall be perpendicular to the main reinforcement.

- 5.7.3 All reinforcing steel shall be continued across joints. Keys and inclined dowels shall be provided as directed by the Engineer. Longitudinal keys at least 1-1/2 inches deep shall be provided in all joints in walls and between walls and slabs or footings.

- 5.7.4 When the work has to be resumed on a surface which has hardened, such surface shall be roughened in an approved manner which will expose the aggregate uniformly and will not leave laitance, loosened particles of aggregate or damaged concrete at the surface.
- 5.7.5 The hardened concrete of construction joints and of joints between footings and walls or columns, between walls or columns and beams or floors they support, joints in un-exposed walls and all others not mentioned herein shall be dampened (but not saturated) immediately prior to placing of fresh concrete.
- 5.7.6 The hardened concrete of joints in exposed work, joints in the middle of beams, and slabs; and joints in work designed to contain liquids shall be dampened (but not saturated) and then thoroughly covered with a coat of cement grout similar in proportions to the mortar in the concrete. The grout shall be as thick as possible on vertical surfaces and at least 1/2 inch thick on horizontal surfaces. The fresh concrete shall be placed before the grout has attained initial set.
- 5.7.7 Where the concrete has not fully hardened, all laitance shall be removed by scrubbing the wet surface with wire or bristle, and brushed, care being taken to avoid dislodgment of particles of aggregate. The surface shall then be coated with neat cement grout. The first layer of concrete to be placed on this surface shall not exceed 6 inch in thickness, and shall be well rammed against old work, particular attention being paid to corners and closed spots.
- 5.7.8 Stop ends for movement joints or construction joints shall be made by splitting them along the lines of reinforcement passing through them, so that each portion can be positioned and removed separately without disturbance or shock to the reinforcement or the concrete. Stop ends made of expanded metal or similar material may only be left permanently in the concrete with prior written approval of the Engineer. Where such stop ends are used, no metal may be left permanently in the concrete closer to the surface of the concrete than the specified cover to the reinforcement.

5.8 **Expansion Joints**

Expansion joints shall be provided wherever indicated on the Drawings or as directed by the Engineer. In no case shall the reinforcement, corner protection angles, or other embedded items be permitted to extend continuously through any expansion joint.

All expansion joints shall be carefully placed so as not to be displaced during concreting. The method of placing the expansion joints shall be strictly in accordance with the Drawings and/or as directed by the Engineer. All materials for use in the expansion joints shall have prior approval of the Engineer before placing order for supply.

5.9 **Embedded Items**

- 5.9.1 The material, design and location of water-stops in joints shall be as indicated in the Contract Documents. Each piece of pre-molded water stop shall be of maximum practicable length in order that the number of end joints will be held to a minimum.

Joints at intersections and at ends of pieces shall be made in the manner most appropriate to the material being used. Joints shall develop effective water-tightness fully equal to that of the continuous water-stop material, shall permanently develop not less than 50 percent of the mechanical strength of the parent section and shall permanently retain their flexibility.

- 5.9.2 Electric conduits and other pipes which are planned to be embedded shall not, with their fittings, displace more than four percent of the area of the cross

section of a column on which stress is calculated or which is required for fire protection. Sleeves, conduits, or other pipes passing through floors, walls, or beams shall be of such size or in such location as not to impair unduly the strength of the construction; such sleeves, conduits, or pipes may be considered as replacing structurally in compression the displaced concrete, provided that they are not exposed to rusting or other deterioration, are of uncoated or galvanized iron or steel not thinner than standard steel pipe, have a nominal inside diameter not over 2 inch and are spaced not less than three diameters on centers. Except when plans of conduits and pipes are approved by the Engineer, embedded pipes and conduits other than those merely passing through, shall not be larger in outside diameter than one third the thickness of the slab, wall, or beams in which they are embedded nor so located as to impair unduly the strength of the construction. Sleeve pipes, or conduits of any material not harmful to concrete and within the limitations of this section may be embedded in concrete with the approval of the Engineer provided they are not considered to replace the displaced concrete.

- 5.9.3 All sleeves, inserts, anchors, and embedded items required for adjoining work or for its support shall be placed prior to concreting.

All Contractors whose work is related to the concrete or must be supported by it shall be given ample notice and opportunity to introduce and/or furnish embedded items before the concrete is placed.

- 5.9.4 Expansion joint material, water-stops and other embedded items shall be positioned accurately and supported against displacement. Voids in sleeves, inserts and anchor slots shall be filled temporarily with readily removable material to prevent the entry of concrete into the voids.

5.10 **Pre-Cast Concrete**

Pre-cast concrete units shall be fair faced (OR WITH ARCHITECTURAL FINISH or with an approved pattern finish) cast to the sizes and dimensions as indicated on the Drawings. The concrete used for pre-cast units shall conform to the specifications laid down for cast in situ reinforced cement concrete unless otherwise required and directed by the Engineer.

The Contractor shall be required to submit a sample of pre-cast unit for the approval of the Engineer; all pre-cast units shall strictly conform to the approved sample.

Pre-casting platform of the size and at the location approved by the Engineer shall be constructed. The concrete in one pre-cast unit shall be placed in one operation, in accordance with the details shown on the Drawings.

The material and design of formwork and the method of pre-casting the units shall be approved by the Engineer.

The erection/installation and removal of the pre-cast units from the pre-casting platform shall not be permitted until and unless they are properly cured to the satisfaction of the Engineer.

All pre-cast units shall be smoothly finished to the required lines, grades, angles, etc. Holes, grooves, pockets and hooks shall be provided as shown and/or as directed by the Engineer. The units shall be properly stacked on a platform without causing any cracks and damages. Curing of all the pre-cast units shall be done in accordance with the relevant BS code/approval of the Engineer.

5.10.1 Erecting Pre-cast Units

All the pre-cast units shall be transported and erected into position in a manner as approved by the Engineer.

The Contractor shall submit his proposal in this regard and obtain approval from the Engineer in advance.

5.10.2 Lifting Beams

The Contractor shall use lifting beams at his own cost for erecting pre-cast members where the Engineer so directs. Lifting beams shall be supplied and erected by the Contractor, at his own cost, at all points where lifting is necessary for maintaining the plant but is inaccessible to mobile cranes or, alternatively, covered by overhead traveling cranes. The Contractor, however, is to supply the trolleys and erect them on the lifting beams, and to test operation of installed equipment.

5.11 **Cement Concrete Pavements**

For all concrete work relevant specifications of this section shall apply.

5.11.1 Side Forms and Construction

Side forms shall be of steel or any other suitable material and of a design as approved by the Engineer.

In general, only materials and methods that have proved their acceptability by past performance will be considered. All form shall be constructed so that they can be removed without hammering or prying against the concrete.

Horizontal joints in the forms will not be permitted. Forms shall be thoroughly cleaned and oiled with linseed/mineral oil shall be given two coats of niter-cellulose lacquer each time they are used.

The forms shall be set on a thoroughly compacted base true to line and level and firmly secured in position by appropriate methods. Conformity with the alignment and levels shown on the Drawings shall be checked as and when required by the Engineer. Where necessary corrections shall be made immediately before placing the concrete; where any form has been disturbed it shall be reset and rechecked.

Pavements shall be constructed in panels of sizes as shown on the Drawings. The panels shall be laid alternately, the adjoining panels being concreted when the side forms are struck and the jointing materials placed, inspected and approved by the Engineer. Each panel is to be concreted in one operation and no interruptions shall be permitted during the operation. The concrete shall be tipped from the trolley slightly in advance of the working place and then shoveled into position. The spreading shall be carried out very carefully. Compaction shall be done by means of vibro-compactors of approved surface vibrators. If a vibro-compactor is used, it shall be operated on the concrete and will not be allowed to strike or displace the forms. The spreading and compacting of the successive layers shall proceed without interruptions and as quickly as practicable so as to ensure that the slab is monolithic throughout its depth.

The wearing surface shall be laid while the base concrete is still wet and screeded to line and level. When the initial set takes place the surface shall be troweled smooth with a steel trowel to provide a dense closed surface.

All the joints shall be carefully formed as shown on the Drawings or as directed by the Engineer. The joint filler together with performed groove shall provide complete separation of adjacent slabs. The joints shall all be sealed with bitumen as shown on the Drawings and as directed by the Engineer.

5.11.2 Protection and Curing

- General Requirements:

Concrete shall be protected adequately from injurious action by sun, rain, flowing water and mechanical injury, and shall not be allowed to dry from the time it is placed until the expiry of the minimum curing periods specified hereinafter. Water curing shall be accomplished by keeping the surface of the concrete continuously wet by covering with water or with an approved water saturated covering. Where wood forms are left in place for curing, they shall be kept sufficiently damp at all times to prevent openings at the joints and drying out of the concrete. All portions of the structure shall be kept moist for the full curing periods, specified hereinafter.

When liquid membrane curing compound is used the surface of the concrete shall be protected from traffic or other abrasive action that may break the membrane, for the full period of curing. The membrane curing compound shall be colourless or light coloured and shall be approved by the Engineer and shall comply with ASTM Designation C 309.

- Curing Periods

The curing period shall be at least 10 days, or as directed by the Engineer.

- Removal of Forms

The Contractor shall exercise great care in avoiding damage to joints, arises, dowel bars etc., while removing the forms. Under no circumstances will the use of pry bars between the forms and pavement be permitted. Side forms shall not be removed until at least 40 hours have elapsed from the time of completing the concreting of the slab which they contain. In no case shall forms be removed until the concrete has hardened sufficiently to permit removal without damage to the concrete. Concrete work shall be protected from injury resulting from the storage or movement of material during construction.

5.11.3 Finishing

All unformed surfaces shall be finished with a wood float except as otherwise specified. Visible vertical surfaces shall have all projections and irregularities removed. The entire surface shall be rubbed if required by the Engineer, with a No. 16 carborundum brick, or other abrasive until even, smooth and of uniform appearance, and shall be shed clean. Plastering of surface, application of cement or other coating will not be permitted.

All exposed corners shall be chamfered, 1"x 1" (2.5 cms x 2.5 cms) unless otherwise mentioned or shown on the plans or directed by the Engineer. Concrete surfaces which will be covered with other materials shall be screeded without floating.

5.11.4 Spreading, finishing and floating of concrete in pavements

- General Requirements

The striking off, compacting and floating of concrete shall be done by mechanical methods, if approved by the Engineer. Where the Engineer determines that it is impracticable to use mechanical methods, manual methods of spreading, finishing and floating may be used on pavement lines as indicated on the Drawings.

- Mechanical Methods

The concrete shall be spread uniformly between the forms, immediately after it is placed, by means of an approved spreading machine. The spreader shall be followed by an approved finishing machine equipped with two oscillating or reciprocating screeds. The spreading machine or the finishing machine shall be equipped with vibrating equipment that will vibrate the concrete for the full paving width. Internal vibrators shall be used adjacent to the longitudinal edge of the pavement. These vibrators shall be attached to the rear of the spreading machine or to the finishing machine. Vibrators shall not rest on view pavements or side forms or in contact with any dowel bars and the arrangement of power supply to the vibrators shall be such that when the motion of machine is stopped, vibration shall cease. The rate of vibration shall be not less than 8000 vibrations per minute. The concrete shall be spread to full width before being struck off and compacted so that the surface will conform to the finished grade and cross-section as shown on the plans and at the same time leave sufficient material for the floating operation. The spreading & finishing machine shall move over the pavement as many times and at such intervals as may be required by the Engineer to ensure thorough compaction.

Except as otherwise specified, after the pavement has been struck off and compacted, it shall be finished with an approved longitudinal float. The Contractor may use a longitudinal float composed of one or more cutting and smoothing floats, suspended from and guided by rigid frame. The frame shall be carried by four or more visible wheels riding on and constantly in contact with the forms.

The contractor may use a longitudinal float which works with a sawing motion, while held in a floating position parallel to the road centre line and passing gradually from one side of the pavement to the other. Movements ahead, along the centre line of the road, shall be in successive advances of not more than half the length of the float.

Instead of using other type of longitudinal float a single machine which will affect satisfactory compaction, finishing and floating may be used. This machine may be towed by a spreading machine. This combination, finishing floating machine shall be equipped with screeds and vibrators as hereinafter specified for spreading and finishing machine. Floating shall be accomplished by means of a non-oscillating float held in a suspended position from the frame.

If any spreading, finishing and floating equipment is not maintained in full working order or if the equipment as used by the Contractor proves inadequate to obtain the results prescribed, such equipment shall be improved or satisfactory equipment substituted or added at the direction of the Engineer.

- Manual Methods

When striking-off and compacting by manual methods is permitted, the concrete shall be leveled and then struck-off to such an elevation that, when properly compacted, the surface will conform to the required grade and cross-section. The strike board shall be moved forward with a combined longitudinal and transverse motion, the manipulation being

such that neither end is raised from the side forms during the process. While striking off, a slight excess of concrete shall be kept in front of the cutting edge at all times. Prior to tamping, the concrete along the forms shall be thoroughly spaded or vibrated. The entire area of pavement shall be tamped or vibrated a manner that will ensure maximum compaction. The concrete shall be brought to the required grade and shape by the use of a tamper consisting of a heavy plank whose length exceeds the width of the pavement by 1 foot or by the use of a mechanical vibrating unit spanning the full width of the spread. The tamper shall be constructed with properly trussed roads to stiffen it and prevent sag and shall be shod with a heavy strip or metal for a tamping surface. The tamper shall be moved with a combined tamping and longitudinal motion, raising it from side form and dropping it so that the concrete will be thoroughly compacted and rammed into place. A small surplus material is compacted and rammed into front of the tamper or vibrating unit and tamping or vibrating shall continue until the true cross-section is obtained and the mortar flushes slightly to the surface.

On grades in excess of 5 percent where hand methods are permitted, a little strike board shall follow at a speed of 25 ft to 50 ft per hour back of the heavy strike board, and shall be used in the same way, so as to remove waves caused by flow of concrete.

Where hand tamping is permitted, not less than two strike boards or tampers shall be used for production in excess of 350 Cu.ft. After the concrete has been compacted, it shall be smoothed with a wooden float where necessary, as directed by the Engineer.

- Longitudinal Floating

Manual floats shall be at least 12 ft. in length not less than 6 inches in width and shall be properly stiffened to prevent bending or warping. In using the float, it shall be held parallel to centre line of the pavement at all time and shall be moved laterally across the pavement from one side or edge to the other until all high areas are cut down and floated into depressions, leaving a surface that is smooth and true to grade. Batch transverse passage of the longitudinal manual float shall lap the proceeding passage by half.

- First Straight Edge Testing

Immediately following final floating the entire area of the pavement shall be tested with a 10 ft. (approx. 3. meters) straight edge. Any depressions found shall be immediately filled with fresh concrete which shall be struck off compacted and finished. High areas shall be worked down and refinished. The straight edge testing and refloating shall continue until the pavement has the required surface contour.

- Burlap (Coarse Canvas) Dragging

After the first straight edge testing and when most of the water sheet has disappeared from the surface and just before the concrete becomes non-plastic, the surface shall be dragged with a strip of burlap (coarse canvas) 3 ft. to 10 ft. wide and having a length 4 ft. more than the width of the slab. The burlap shall be dragged along the surface of the pavement in a longitudinal direction. Burlap shall be clean and kept free from coatings of hardened concrete. It shall be moist at the time of use.

- Second Straight Edge Testing

After the concrete has hardened sufficiently to permit walking on it, the surface of the pavement shall again be tested with a 10 ft. straight

edge. Any portion of the pavement which shows a variation from the testing edge of more than 1/8 inch shall be corrected by cutting, or shall be removed and replaced at the expense of the Contractor.

5.11.5 Expansion and Contraction Joints

- i. All the expansion and contraction joints shall be carefully formed as shown on the Drawings or as directed by the Engineer. As regards dowel bars and joint assemblies, such stakes, brackets or other devices shall be used, as necessary to keep the entire joint assembly in true vertical and horizontal position. The joint filler together with the preformed groove shall provide complete separation of adjacent slabs. The joints shall all be sealed with the specified non-extruding sealing compound set in a 3/4 inch wide preformed chase as shown on the Drawings. The preformed chase shall be thoroughly cleaned of all dust, debris, stones or other hard material prior to its sealing. The riser of all joints shall be rounded to a radius as shown on the Drawings before the concrete hardens.
- ii. The joints sealing compound shall be hot poured bitumen or approved sealing compound for concrete pavements complying with BS-2499 for hot tropical climates and heavy duty industrial site subject to severe exposure. All joints are to be filled with flexcell expansion joint filler, or an approved elastic, compressible, durable and rot-proof equivalent of sufficient rigidity to enable it to be satisfactorily installed in the joint and resist deformation during the passage of the concreting equipment. The filler is to be of the same thickness as the joint width. Holes to accommodate the dowel bars shall accurately be drilled or punched out. Where shown on the Drawings, dowel bars of required diameter shall be placed at the specified spacing. The bars shall be lubricated with an approved lubricant. One end of the dowel bar at expansion joints shall be provided with a closely fitting sleeve 3 inch long, consisting of bitumen coated plastic or other approved material to permit expansion. A loose plug 1 inch deep of approved compressible filling material shall be inserted into the sleeve as shown on the Drawings at the end of the bar. All the dowel bars shall be mild steel bars of the size shown on the Drawings and shall conform to the requirements as specified in the section 'Concrete'.
- iii. Contraction joints shall be provided as shown on the Drawings.

The assembly and method of constructing the expansion joints/contraction joints shall be subject to the approval of the Engineer.

5.12 Consolidation

- 5.12.1 All concrete shall be consolidated by vibration, spading, rodding or forking so that the concrete is thoroughly worked around the reinforcement, around embedded items and into corners of forms, eliminating all air or stone pockets which may cause honeycombing, pitting, or planes of weakness. Internal vibrators shall have a minimum frequency of 8000 vibrations per minute and sufficient amplitude to consolidate the concrete effectively. They shall be operated by competent workmen. Use of vibrators to transport within forms shall not be allowed. Vibrators shall be inserted and withdrawn at points approximately 18 inch apart. At each insertion, the duration shall be sufficient to consolidate the concrete but not excessive so as to cause segregation, generally from 5 to 15 sec. A spare Vibrator shall be kept on the job site during all concrete placing operations.

Where the concrete is to have an as-cast finish, a full surface of mortar shall be brought against the form by the vibration process, supplemented, if necessary, by spading to work the coarse aggregate back from the formed surface.

- 5.12.2 If there is any tendency for the mix to segregate during consolidation, particularly if this produces excessive laitance, the mix proportions shall be modified to effect an improvement in the quality of the concrete to the satisfaction of the Engineer and in conformity with the provisions of Clause 5.
- 5.12.3 Vibrator shall not be allowed to contact the form work for exposed concrete surfaces.
- 5.12.4 Mechanical vibrators shall be of a type suited in the opinion of the Engineer to the particular conditions.
- 5.12.5 Over-vibration or vibration of very wet mixes is harmful and should be avoided.

5.13 **Curing and Protection**

- 5.13.1 Beginning immediately after placement, concrete shall be protected from premature drying, excessively hot or cold temperatures and mechanical injury and shall be maintained with minimum moisture loss at a relative constant temperature for the period necessary for hydration of the cement and hardening of the concrete. The materials and methods of curing shall be subject to approval of the Engineer.
- 5.13.2 For concrete surfaces not in contact with forms, one of the following procedures shall be applied immediately after completion of placement and finishing:
 - Ponding or continuous sprinkling.
 - Application of absorptive mats or fabric kept continuously wet.
 - Application of waterproof sheet materials approved by the Engineer.
 - Application of other moisture-retaining covering as approved.
 - Application of a curing compound conforming to ASTM C 309.

The compound shall be applied in accordance with the recommendations of the manufacturer immediately after any water sheen which may develop after finishing has disappeared from the concrete surface. It shall not be used on any surface against which additional concrete or other material is to be bonded unless it is proved that the curing compound will not prevent bond, or unless positive measures are taken to remove it completely from areas to receive bonded applications.

- 5.13.3 Moisture loss from surfaces placed against wooden forms or metal forms exposed to heating by the sun shall be minimized by keeping the forms wet until they can be safely removed. After form removal the concrete shall be cured until the end of the time prescribed for curing.
- 5.13.4 Curing in accordance with sub-clause 5.13.1 & 5.13.2 above shall be continued for at least 10 days in the case of all concrete except concrete with rapid-hardening Portland Cement for which the period shall be at least 3 days. Alternatively, if tests are made of cubes kept adjacent to the structure and cured by the same methods, moisture retention measures may be terminated when the average compressive strength has reached 70 percent of the minimum specified works cube strength. If one of the first four curing procedures of sub-clause 5.13.2 is used initially, it may be replaced by one of

the other procedures of that sub-clause any time after the concrete is one day old provided the concrete is not permitted to become surface dry during the transition.

- 5.13.5 When the mean daily outdoor temperature is less than 5 degree C (41 deg. F) temperature of the concrete shall be maintained between 10 and 20 degrees C (50 to 68 deg. F) for the required curing period of sub-clause 5.13.4.

When necessary, arrangements for heating, covering insulation or housing the concrete work shall be made in advance of placement and shall be adequate to maintain the required temperature without injury due to concentration of heat. Combustion heaters shall not be used during the first 24 hours unless precautions are taken to prevent exposure of the concrete to exhaust gasses which contain carbon dioxide.

- 5.13.6 During hot weather when necessary, provision for wind-brakes, shading for spraying, sprinkling, ponding or wet covering with a light coloured material shall be made in advance of placement. Such protective measures shall be taken as quickly as concrete hardening and finishing operation will allow.

- 5.13.7 Changes in temperature of the air immediately adjacent to the concrete during and immediately following the curing period shall be kept as uniform as possible and shall not exceed 3 deg. C (37 deg. F) in any one hour or 10 degree C (50 deg. F) in any 24 hour period.

- 5.13.8 During the curing period, the concrete shall be protected from damaging mechanical disturbances, such as load stresses, heavy shock and excessive vibrations. All finished concrete surfaces shall be protected from damage by construction equipment, materials or methods by application of curing procedures, and by rain or running water. Self-supporting structures shall not be loaded in such a way as to over stress the concrete.

5.14 **Works in Extreme Weather**

- 5.14.1 Unless adequate protection is provided and approval is obtained from the Engineer, concrete shall not be placed during rain.

Rain water shall not be allowed to increase the mixing water nor to damage the surface finish.

- 5.14.2 When the temperature of the surrounding air is expected to be below 5 deg. C during placing or within 24 hours thereafter, the temperature of the plastic concrete, as placed, shall be no lower than 13 deg. C for sections less than 12 inch in any dimension nor 10 deg. C for any other sections.

When necessary, concrete material should be heated before mixing and carefully protected after placing, in general, heating or mixing water alone to about 60 deg. C may be sufficient for this purpose. Dependence should not be placed on salt or other chemicals for the prevention of freezing. No frozen material or materials, containing ice shall be used. All concrete damaged by frost shall be removed. It is recommended that concrete exposed to the action of freezing weather should have entrained air and the water content of the mix should not exceed 5.5 gallon/bag of cement.

If water or aggregate is heated above 38 deg. C the water shall be combined with the aggregate in the mixer before cement is added. Cement shall not be mixed with water or with mixtures of water and aggregate having a temperature greater than 38 deg. C.

- 5.14.3 During hot weather, the temperature of the concrete as placed shall not be so high as to cause difficulty from loss of slump, flash set, or cold joints and should not exceed 32 deg. C. For massive concrete, this temp. should not exceed 21 degree C. When the temp. of the concrete exceeds 32 degree C,

precautionary measures approved by the Engineer shall be put into effect. When the temperature of the steel is greater than 50 deg. C, steel forms and reinforcement shall be sprayed with water just prior to placing the concrete. The ingredients shall be cooled before mixing, or flaked ice or well crushed ice of a size that will melt completely during mixing may be substituted for all part of the mixing water if, due to high temperature, low slump, flash set or cold joints are encountered.

Other precautions recommended by ACI Standard 305-72 shall also be adopted.

6. TEST OF CONCRETE QUALITY

- 6.1 The Contractor shall provide samples of concrete for testing at the Engineer's direction. Proper facilities shall be provided for making and curing the test specimens in accordance with PS 560 and PS 849. A competent person shall be employed by the Contractor whose first duty shall be to supervise all stages in the preparation and placing of the concrete. All test specimens shall be made and site tests carried out under his direct supervision.
- 6.2 Preliminary cube tests and works cube test shall be performed in accordance with PS 560 and PS 849 at the discretion of the Engineer. Works transverse tests shall be performed in accordance with sub-clauses 208 c and 610 d of CP 114. The standard of acceptance for preliminary and works tests shall be as given below.
- 6.3 The usual test for concrete with maximum size of aggregate upto 1-1/2 inch is the 6 inch cube tested in compression. Details of making and curing compression test cubes are given in PS 560, PS 849 and BS 1881 and details of the testing are given in Part 8 of BS 1881.
- 6.4 For all grades of concrete, preliminary cube strength test with the mixes and materials to be used shall be performed in accordance with PS 560, PS 849 and BS 1881 before the work is begun and subsequently whenever any change is to be made in the materials or in the proportions of materials to be used, or as required by the Engineer. The strengths shall comply with the standard of quality specified in accordance with Table 1 for preliminary tests. The cost of such testing shall be borne by the Contractor.
- 6.5 Test sample shall be taken at the mixer or as directed by the Engineer. The test specimens shall be cured in accordance with PS 560, PS 849 and BS 1881.

Records shall be kept of all test cubes identifying the mix used, the section of work for which the concrete was used and the date poured.
- 6.6 Five test cubes are to be tested for compressive strength as specified in BS 1881. These tests shall be carried out at site or in a laboratory approved by the Engineer. Two cubes shall be tested at the age of seven days and three at 28 days and the strengths determined are to comply with the standard of quality specified. The laboratory tests shall be carried out by an independent organization, such as Government Testing Laboratory or such other undertakings approved by the Engineer. The original test reports received from the above authorities should be submitted to the Engineer.
- 6.7 For all grades of concrete, the appropriate strength requirement shall be considered to be satisfied if none of the strengths of the cubes is below the specified cube strength or if the average strength of the three cubes is not less than the specified cube strength and the difference between the greatest and the least strength is not more than 20% of the average.
- 6.8 When the results of works cube tests show that the strength of any concrete is below the minimum specified, the Engineer may give instructions for the whole or part of the work concerned to be removed and replaced at the expense of the Contractor. The Contractor shall bear the cost of any other part of his, or any other contractor's work, which has to be removed and replaced as a result of the defective concrete. If any

concrete is held to have failed, the Engineer may order the proportions of that class of concrete to be changed in order to provide the specified strength.

7. FINISHING OF FORMED SURFACES

7.1 General

- 7.1.1 After removal of forms, the surfaces of concrete shall be given one or more of the finishes specified below in locations designated by the Contract Documents.
- 7.1.2 When finishing is required to match a small sample furnished to the Contractor, the sample finish shall be reproduced on an area at least 100 Sq. ft. in an inconspicuous location designated by the Engineer before proceeding with the finish in the specified location.
- 7.1.3 Allowable deviations from plumb or level and from the alignment, profile grades, and dimensions are specified in clause 9. Tolerances for concrete construction and defined as tolerances that are to be distinguished from irregularities in finish as described herein. The finish requirements for concrete surfaces shall be as generally specified in this clause and as indicated on the Drawings. Finishing of concrete surfaces shall be performed only by workmen who are skilled in concrete finishes. The Contractor shall keep the Engineer advised as to when finishing of concrete will be performed. Unless inspection is waived in each specific case, finishing of concrete shall be performed only in the presence of the Engineer. Concrete surfaces will be tested by the Engineer where necessary to determine whether surface irregularities are within the limits herein after specified. Surface irregularities are classified as abrupt or gradual.

Offsets caused by displaced or misplaced form sheeting or lining or sections, or otherwise defective form lumber will be considered as abrupt irregularities, and will be tested by direct measurements. All other irregularities will be considered as gradual irregularities, and will be tested by use of a template, consisting of a straight edge or the equivalent thereof for curved surfaces. The length of the template will be 6.5 ft. for testing of formed surfaces and 10 ft. for testing of unformed surfaces.

7.2 As-cast Finishes

Unless otherwise specified or indicated on the Drawings the classes of finish shall apply as follows:

7.2.1 Rough form finish:

No selected form facing materials shall be specified for rough form finish surfaces. Tie holes and defects shall be patched. Fins exceeding 1/4" in height shall be chipped off or rubbed off. Otherwise, surfaces shall be left with the texture imparted by the forms.

7.2.2 Fair face finish:

Fair face finish applies to concrete formed surfaces, the appearance of which is considered by the Engineer to be of special importance, such as surfaces of structures prominently exposed to public inspection. Surfaces of concrete structures requiring fair face finish is shown in the Drawings. Surface irregularities, measured as described in sub-clause 7.2.1, 'Rough form finish', shall not exceed 1/4 inch for gradual irregularities and 1/8 inch for abrupt irregularities, except that abrupt irregularities will not be permitted at construction joints. Abrupt irregularities at construction joints and elsewhere in excess of 1/8 inch and gradual irregularities in excess of 1/4 inch shall be reduced by grinding so as to conform to the specified limits. Abrupt

irregularities at construction joints shall be ground on level of 1 to 20 ratio of height to length.

Unless otherwise approved, repair of imperfections in formed concrete shall be completed within 24 hours after removal of forms. The form facing material shall produce a smooth, hard, uniform texture on the concrete. It may be plywood, tempered concrete-form-grade hardboard, metal, plastic paper or other approved material capable of producing the desired fair face finish. The arrangement of the facing material shall be orderly and symmetrical, with the number of seams kept to the practical minimum. It shall be supported by studs or other backing capable of preventing excessive deflection. Material with raised grain, torn surfaces, worn edge, patches, dents, or other defects which will impair the texture of the concrete surface shall not be used. Tie holes and defects shall be patched. All fins shall be completely removed.

7.2.3 Architectural Finish Concrete:

Architectural finish to concrete formed surfaces as shown on the Drawings is required by the Engineer where the architectural appearance of surfaces of structures exposed to public view is of special consideration and importance. The Contractor shall use approved special material for formwork and design the forms in conformity with the specified architectural patterns, textures and finishes in order to obtain first class architectural finish on formed concrete surface without any defect, irregularities, blemishes, imperfections and encrustation's.

Samples:

1. Submit to the Engineer a minimum of two units or portions of units of each Precast item required. Each pair of samples when accepted will describe the allowable limits between which variations can be acceptable.
2. Similar samples of in-situ concrete for approval by the Engineer, submit two samples, 2 Sq. ft. of each type of exposed in-situ concrete. All in-situ samples will remain at the construction site.

Sample approvals of Precast & in-situ concrete:

These samples will be reviewed and approved on the basis of colour, dimensional accuracy, finish of surfaces and general appearance. The same requirements for sample approval will be required for both Precast and in-situ concrete exposed surfaces.

Forms

The contractor must maintain the forms unusually tight and braces to prevent movement, mal-alignment and bleeding that will result in sand streaks, honeycomb, fins, stain or unsightly appearance.

If wood forms are chosen to be used by the Contractor they shall be constructed of 3/4 inch minimum thickness plywood constructed in a fashion to allow many re-uses with all surfaces sealed with a polyurethane varnish.

Edges, surfaces and corners of forms shall be sealed to prevent loss of any matrix or unequal absorption of water. Corners of wood forms shall be filled with suitable compound and all contact surfaces sealed with a polyurethane varnish.

Re-use of forms shall be subject to approval by the Engineer.

Curing:

Curing shall be done in shade (out of direct sunlight) and shall be for a minimum period of 4 days.

Finishing procedures:

"Finishing procedures for filling air void in smooth finished concrete developed by a formed surface":

While the concrete surface is still damp (not more than three days after removal of forms), apply a thin coat of medium consistency neat cement slurry by means of bristle brushes to provide a bonding coat within any pits or blemishes in the parent concrete; avoid coating large areas of the finished surface. Before slurry has dried or changed colour, apply a dry (almost crumbly) grout comprised of one part cement, of the type and brand of cement used in the original concrete, to one and one-half parts clean masonry sand with a fineness modulus of approximately 2.25 and complying with the gradation requirements of the ASTM Specifications C 144. Mix proper amounts of white cement and colouring with the parent mortar to produce a satisfactory colour match with the parent concrete after hardening. Use samples previously prepared.

Apply the finishing grout uniformly with damp (neither dripping wet nor dry) pads of coarse burlap approximately 6 inch square used as a float. Scrub the grout well into the pits to provide a dense mortar in all the imperfections to be filled. Allow the mortar to partially harden, from one to two hours, depending upon the weather. Avoid direct hot sunlight. If the air is hot and dry, keep the concrete surface damp during this period using a fine fog spray. When the grout has hardened sufficiently so it can be scraped from the surface with the edge of a steel trowel without damaging the grout from the small pits or holes, cut off all that can be removed with a trowel without delay; next allow the surface to dry thoroughly and rub it vigorously with clean, dry burlap to completely remove any dried grout. No visible film of grout shall remain after this rubbing. Complete the entire cleaning and grouting operation for the grout to dry after it has been cut with the trowel, so it can be wiped off clean with the burlap.

On the day after the repair work, the concrete surfaces should again be wiped off clean with dry burlap to remove any inadvertent dust; leave no built-up surfaces on the parent surfaces. Employ, if possible, a used piece of burlap containing old hardened mortar to act as a mild abrasive. Use of fine abrasive stone if needed to remove any remaining built-up film without breaking through the surface film of the original concrete. Such scrubbing should be light and sufficient only to remove excess material without working up a lather of mortar or changing the texture of concrete.

Following the final bagging or stoning operation, provide a thorough wash down with stiff bristle brushes to remove all extraneous materials and spray the concrete surface with a fine fog spray periodically to maintain a continually damp condition for at least three days after application of the pit repair grout.

Rust Stains:

All rust stains are to be removed employing the following procedure:

The rust stain shall be soaked for 10 minutes with a solution of 0.055 lb. of sodium citrate in 0.33 lb. water (brushing the solution at short intervals is satisfactory). Then the surface is sprinkled with crystals of sodium hydrosulfite and covered with a paste of Fuller's Earth and water. On a vertical surface, the

paste is applied with a trowel, with the crystals first sprinkled on the paste so they will be in direct contact with the stain. The paste is allowed to dry for 10 minutes then scraped off and the treatment repeated if necessary.

Repairing of Formed Surfaces:

It is the intention of Specification to require forms, mixture of concrete and workmanship so that concrete surfaces, when exposed, will require no patching. Any concrete which is not formed as required and conforming to approved samples or for any reason is out of alignment or level or shows a defective surface, shall be removed from the job by the Contractor at his expense unless the Engineer grants permission to repair the defective area. Permission to patch any such area shall not be considered a waiver of the Engineer's right to require a complete removal of defective work if the repair does not, in his opinion, satisfactorily restore the quality and appearance of the surface. The Engineer shall be the sole judge of acceptability of appearance.

7.3 **Finishes of Unformed Surfaces:**

7.3.1 **Monolithic Concrete Floor Finish'**

Where monolithic concrete floor finish is shown on the Drawings, placing shall proceed continuously for the full thickness of the course or RCC slab without change in concrete mix. Mixing water shall be the minimum required for proper placing, and will be as specified by the Engineer. After placing, floors, and other surfaces shall be floated with a wood float to a true surface and to elevation as shown on the Drawings. Where indicated on the Drawings, floor surfaces shall be steel trowel finished. Troweling shall be the minimum amount consistent with maintaining a smooth dense surface, and shall not be done until the mortar has hardened sufficiently, to prevent excess fine material from being worked to the surface, and shall produce a dense uniform surface, free from blemishes and trowel marks.

Gradual surface irregularities shall not exceed 1/16 inch. The addition of water, dry cement, or dry cement mortar, to the surface of the concrete to facilitate finishing will not be permitted.

7.3.2 **Equipment Foundations'**

Unless otherwise specified, exposed, surfaces of equipment foundations shall be given steel trowel finish to produce a surface similar to the specified concrete floor finish.

8. **REPAIR OF SURFACE DEFECTS**

8.1 **General**

8.1.1 Any concrete failing to meet the specified strength or not formed as shown on drawings, concrete out of alignment, concrete with surfaces beyond required tolerances or with defective surfaces which cannot be properly repaired or patched in the opinion of the Engineer shall be removed at Contractor's cost. The Engineer may reject any defective concrete and order it to be cut out in part or in whole and replaced at the Contractor's expense.

8.1.2 All ties and bolt holes and all repairable defective areas shall be patched immediately after form removal.

8.2 **Repair of Defective Areas**

- 8.2.1 All honeycombed and other defective concrete shall be removed down to sound concrete. The area to be patched and an area at least 6 inch wide surrounding it shall be dampened to prevent absorption of water from the patching mortar. A bonding grout shall be prepared using a mix of approximately 1 part cement to 1 part fine sand passing No.25 BS Sieve and shall then be well brushed into the surface.
- 8.2.2 The patching mixture shall be made of the same material and of approximately the same proportions as used for the concrete, except that the coarse aggregate shall be omitted and the mortar shall consist of not more than 1 part cement to 2-1/2 parts sand by damp loose volume. White Portland cement shall be substituted for a part of the gray Portland cement on exposed concrete in order to produce a colour matching the colour of the surrounding concrete, as determined by a trial patch.
- 8.2.3 The quantity of mixing water shall be no more than necessary for handling and placing. The patching mortar shall be mixed in advance and allowed to stand with frequent manipulation with a trowel, without addition of water, until it has reached the stiffest consistency that will permit placing.
- 8.2.4 After surface water has evaporated from the area to be patched, the bond coat shall be well brushed into the surface. When the bond coat begins to lose the water sheen, the premixed patching mortar shall be applied. The mortar shall be thoroughly consolidated into place and struck off so as to leave the patch slightly higher than the surrounding surface. To permit initial shrinkage, it shall be left undisturbed for at least 1 hour before being finally finished. The patched area shall be kept damp for 7 days. Metal tools shall not be used in finishing a patch in a formed wall which will be exposed.
- 8.2.5 Where as-cast finishes are specified, the quantity of patched area shall be strictly limited. The combined total of patched areas in as-cast surfaces shall not exceed 2 sq.ft. in each 1000 sq.ft. of as-cast surface. This is in addition to form tie patches, if the project design permits ties to fall within as-cast areas.
- 8.2.6 Any patches in as-cast architectural concrete shall be indistinguishable from surrounding surfaces. The mix formula for patching mortar shall be determined by trial to obtain a good colour match with the concrete when both patch and concrete are cured and dry. After initial set, surfaces of patches shall be dressed manually to obtain the same texture as surrounding surfaces.
- 8.2.7 Patches in architectural concrete surfaces shall be cured for 7 days. Patches shall be protected from premature drying to the same extent as the body of the concrete.

8.3 **Tie and Bolt Holes**

After being cleaned and thoroughly dampened, the tie and bolt holes shall be filled solid with patching mortar. If architectural appearance requires, these holes may be filled partially creating the desired round clear holes pattern on surfaces exposed to view.

8.4 **Proprietary Materials**

If permitted or required by the Engineer, proprietary compounds for adhesion or as patching ingredients may be used in lieu of or in addition to the foregoing patching procedures. Such compounds shall be used in accordance with the manufacturer's recommendations with prior approval of the Engineer.

9. **CONCRETE CONSTRUCTION TOLERANCES**

Where tolerances are not stated in the specifications or drawings for any individual structure or feature thereof, maximum permissible deviations from established lines, grades and dimensions shall conform to the following. The Contractor is expected to set and maintain concrete forms so as to ensure complete work within tolerance limits. These allowable tolerances shall not relieve the Contractor of this responsibility for correct fitting of indicated materials. These tolerances are not cumulative.

- 9.1 Variation from the plumb (or the specified batter for inclined walls.)
- 9.1.1 In the lines and surfaces of columns, piers, walls and in arrises:
- | | |
|------------------------------------------|----------|
| In any 10 feet of length or height | 1/4 inch |
| In any storey or 20 feet length | 3/8 inch |
| Maximum for the entire length or height. | 1 inch |
- 9.1.2 For exposed corner columns, control joint grooves and other conspicuous lines.
- | | |
|-----------------------------------------|----------|
| In any bay or 20 feet maximum | 1/4 inch |
| Maximum for the entire length or height | 1/2 inch |
- 9.2 Variation from the level or from the grades indicated on the drawings.
- 9.2.1 In floors, ceilings, beams soffits and in arrises measured before removal of supporting shores.
- | | |
|-------------------------------------|----------|
| In any 10 feet of length | 1/4 inch |
| In any bay or in any 20 feet length | 3/8 inch |
| Maximum for the entire length | 3/4 inch |
- 9.2.2 For exposed lintels, sills, parapets, horizontal grooves and other conspicuous lines.
- | | |
|-------------------------------|----------|
| In any bay or 20 feet length | 1/4 inch |
| Maximum for the entire length | 1/2 inch |
- 9.3 Variation of the linear building lines from established position in plan and related position of columns, walls and partitions.
- | | |
|---------------------------------|----------|
| In any bay or 20 feet of length | 1/2 inch |
| Maximum for the entire length | 1 inch |
- 9.4 Variation in the sizes and locations of sleeves, floor openings and wall openings. $\pm 1/4$ inch
- 9.5 Variation in cross-sectional dimensions of columns and beams and in the thickness of slabs and walls.
- | | |
|-------|----------|
| Minus | 1/4 inch |
| Plus | 1/2 inch |
- 9.6 **Footings**
- 9.6.1 Variation in dimensions in plan
- | | |
|------------------------------------------------------------------------------------|----------|
| Minus | 1/2 inch |
| Plus (plus variation applied to concrete only, not to reinforcing bars or dowels). | 2 inch |

9.6.2	Misplacement or eccentricity	2 percent of the footing width in the direction of misplacement but not more than (applies to concrete only, not to reinforcing bars or dowels).	2 inch
9.6.3	Thickness	Decrease in specified thickness	5%
		Increase in specified thickness	No limit
9.7	Variation in Steps		
9.7.1	In a flight of stairs		
	Rise		$\pm 1/8$ inch
	Tread		$\pm 1/4$ inch
9.7.2	In consecutive steps		
	Rise		$\pm 1/16$ inch
	Tread		$\pm 1/8$ inch
9.8	<u>Tolerances for Precast concrete construction</u>		

Forms must be true to size and dimensions of concrete members shown on the plans and be so constructed that the dimensions of the finished products will be within the following limits at the time of placement of these units in the structure, unless otherwise noted on structural-architectural drawings:

9.8.1	Overall dimensions of members		1/16 inch per 10 feet
9.8.2	Cross-sectional dimensions		
	Sections less than 3 inch.		1/16 inch
	Sections over 3 inch and less than 18 inch.		1/8 inch
	Sections over 18 inch.		1/4 inch
9.8.3	Deviations from straight line in long sections.		
	Not more than		1/8 inch per 10 feet.
9.8.4	Deviation from specified camber		$\pm 1/16$ inch per 10 feet span.
	Maximum differential between adjacent units in erected position		1/4 inch.

10. ACCEPTANCE OF STRUCTURE

10.1 General

10.1.1 Completed concrete work which meets all applicable requirements will be accepted subject to the other terms of the Contract Documents.

10.1.2 Completed concrete work which fails to meet one or more of the requirements and which has been repaired to bring it into compliance will be accepted subject to the other terms of the Contract Documents.

10.1.3 Completed concrete work which fails to meet one or more of the requirements and which cannot be brought into compliance may be accepted or rejected as provided in these Specifications or in the Contract Documents. In this event, modifications may be required to assure that remaining work complies with the requirements.

10.2 **Dimensional Tolerances**

10.2.1 Formed surfaces resulting in concrete outlines smaller than permitted by the tolerances of clause 9 shall be considered potentially deficient in strength and subject to the provisions of sub clause 10.4.

10.2.2 Formed surfaces resulting in concrete outlines larger than permitted by the tolerances of clause 9 may be rejected and the excess material shall be subject to removal. If removal of the excess material is permitted, it shall be accomplished in such a manner as to maintain the strength of the section and to meet all other applicable requirements of function and appearance. Permission is required if excess material is to be removed in accordance with this clause.

10.2.3 Concrete members cast in the wrong location may be rejected if the strength, appearance or function of the structure is adversely affected or if misplaced items interfere with other construction.

10.2.4 Inaccurately formed concrete surfaces exceeding the limits of Clause 9 or of Clause 5.6 of Section 'Formwork' and which are exposed to view, may be rejected and shall be repaired or removed and replaced if required.

10.3 **Appearance**

10.3.1 Architectural concrete with surface defects exceeding the limitations of Sub-clause 5.6 of Clause 5 of the Section, 'Formwork' shall be removed and replaced.

10.3.2 Other concrete exposed to view with defects which adversely affect the appearance of the specified finish may be repaired only by approved methods.

10.3.3 Concrete not exposed to view is not subject to rejection for defective appearance.

10.4 **Strength of Structure**

10.4.1 The strength of the structure in place will be considered potentially deficient if it fails to comply with any requirements which control the strength of the structure, including but not necessarily limited to the following conditions.

- Concrete strength requirements not considered to be satisfied in accordance with Clause 6 hereof.
- Reinforcing steel size, quantity, strength, position or arrangement at variance with the requirements as listed under specification of 'Reinforcement' or in the Contract Documents.
- Concrete which differs from the required dimensions or location in such a manner as to reduce the strength.
- Curing less than that specified.

- Inadequate protection of concrete from extremes of temperature during early stages of hardening and strength development.
 - Mechanical injury, construction fires, accidents of premature removal of formwork likely to result in deficient strength.
 - Poor workmanship likely to result in deficient strength.
- 10.4.2 Structural analysis and/or additional testing may be required when the strength of the structure is considered potentially deficient.
- 10.4.3 Core tests may be required when the strength of the concrete in place is considered potentially deficient.
- 10.4.4 If core tests are inconclusive or impractical to obtain or if structural analysis does not confirm the safety of the structure, load tests may be required and their result evaluated in accordance with British Standard BS 8110 or ACI Standard 318.
- 10.4.5 Concrete work judged inadequate by structural analysis or by results of a load test shall be reinforced with additional construction if so directed by the Engineer or shall be replaced, at the Contractor's expense.
- 10.4.6 The Contractor shall pay all costs incurred in providing the additional testing and/or analysis required by this section.
- 10.4.7 The Employer will pay all costs of additional testing and/or analysis which is made at his request and which is not required by these Specifications, or by the Contract Documents.

11. **PVC WATER STOP/HYDROFOIL**

11.1 **Material**

All PVC water stops/hydrofoil shall be central bulb type from a manufacturer approved by the 'Engineer'. The specific gravity of PVC water stop/hydrofoil shall not be less than 1.37 and Full stretch Break cut intensity when tested at normal temperature shall not be less than 1875 psi.

The material shall have a modulus of rigidity of 850 psi at +10° C and 10,500 psi at 20° C.

11.2 **Placing & Connections**

In general all PVC water stops/hydrofoil shall be placed in the centre of the structural member. Each piece of the water stop-hydrofoil shall be of maximum practicable length. An ordinary sharp knife, saw or any other sharp tool can be used to cut the water stop. Joints at inter sections and at ends of pieces shall be made in the manner most appropriate to the material being used. Joints shall develop effective water tightness fully equal to that of the continuous water stop material and shall permanently retain their flexibility. For straight line connection melting method of connection can be used by passing two water stops intended for connection against a heated iron or copper sheet. When they are melted, the two are combined.

After joining, the water stop should be allowed to cool.

For all other connections such as T-type or L-type, the welding method of joining should be used. Welding rod of same material as the water stop shall be used. The welding rod & the water stop shall be heated & melt at the same time, by means of heated air jetting from the hot jet gun.

12. **NON-SHRINK GROUT:**

Grout for placement under base and bearing plates of machinery and equipment, for grouting anchor bars and dowels and for similar uses shall be as follows:-

12.1 **Composition**

- 12.1.1 Non-shrink grout of less than 1 inch thickness shall consist of one part Portland cement and one part of clean sharp sand conforming to the requirements of these specifications and 1:22,000 to 1:15000 part of grained aluminum powder containing non polishing agent.
- 12.1.2 Non-shrink grout of 1 inch or more in thickness shall be proportioned as above except that 1-1/2 parts of 3/8 inch to 1/4 inch pea gravel shall be added.
- 12.1.3 The above specified composition may be varied if required by the Engineer. The Contractor shall, at his own cost, make optimum mix design and testing for approval of the composition.
- 12.1.4 Proportioning shall be done by weight.
- 12.1.5 Mixing water shall be proportioned so as to provide a flowable mixture without segregation or bleeding. Dry packing will not be permitted.

12.2 **Application**

- 12.2.1 Concrete surfaces to receive non-shrinking grout shall be roughened, cleaned and dampened.
- 12.2.2 Form shall be provided to retain the grout until sufficiently hard to support itself.
- 12.2.3 Grout shall be poured in place and thoroughly rodded or washed to prevent the formation of voids.
- 12.2.4 After non-shrink grout has received its initial set, it shall be kept damp for 24 hours.

12.3 **Non-Shrink Second Stage Concrete Grout**

Non-shrink second stage concrete grout shall be provided and placed in position where shown on the Drawings or as directed by the Engineer. Non-shrink concrete mix proportion shall be one part cement two parts coarse clean sand and four parts of coarse aggregates meeting the requirements of these specifications and 1:22,000 to 1:15000 part of grained aluminum powder containing non-polishing agent. Proportioning shall be done by weight.

The above specified composition may be varied if required by the Engineer.

The Contractor shall at his own cost make optimum mix design and testing for approval of the Engineer prior to commencement of the work.

Mixing water and application procedure shall be followed as given in sub-clause 12.2 or as per direction of the Engineer.

13. **VAPOUR BARRIER**

Vapour barrier shall be polyethylene building film, visqueen standard or approved equal. The film shall be 150 micron thick (100 gauge). The quality of material shall be approved by the Engineer prior to use in the works.

Vapour barrier shall be laid in position wherever shown on the Drawings.

The material shall be supplied in rolls and laid by rolling over the prepared surface at the levels and position in the areas shown on the Drawings. Where joint is necessary at the side or end of a sheet, this shall be a double weld folded joint made by placing the edges together and folding over twice continuously taking the top edge prior to concreting. The Contractor shall protect the film sheets from damages during laying and subsequent operations and shall replace at his own cost all damaged film sheets to the satisfaction of the Engineer.

Manufacturer's recommendations and instructions along with the sample of material shall be submitted to the Engineer for his approval.

14. MEASUREMENT AND PAYMENT

14.1 General

Except otherwise specified herein or elsewhere in the Contract Documents, no measurement and payment will be made for the under mentioned specified works related to the relevant items of the Bills of Quantities. The cost thereof shall be deemed to have been included in the quoted unit rate of the respective items of the Bills of Quantities.

The rates quoted by the Contractor in the Bill of Quantities shall include work to be executed under these specification in any floor and at any height except where otherwise specifically stated in the relevant item of Bill of Quantities and the Contractor shall not be entitled to any claim or claim any compensation on this account.

14.1.1 Providing, fixing, striking, etc. of formwork.

14.1.2 Providing, placing and fixing of anchor bolts or any other embedded parts.

14.1.3 Providing and installing all type of joints in concrete structure, including expansion joints.

14.1.4 Providing and fixing water stoppers.

14.2 Plain and Reinforced Concrete

14.2.1 Measurement

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

- Volume of any steel embedded in the concrete.
- Volume occupied by water pipes, conduits etc. not exceeding 10 square inches each in cross-sectional area.
- Voids not exceeding 4 square inch in work given in square feet. If any void exceeds 4 square inch, total void shall be deducted.

Voids, which are not to be deducted as specified above, refer only to openings or vents which are wholly within the boundaries of measured areas. Openings or vents which are at the boundaries of measured areas shall always be subject to deductions irrespective of size.

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

Junction between straight and curved works shall in all cases be deemed to be included with the work in which they occur.

Measurement of walls shall be taken between attached columns piers or pilaster. The thickness of attached columns, piers or pilaster shall be taken as the combined thickness of the wall and the columns, piers or pilaster.

Attached or isolated columns, piers, pilaster, and the like (except where caused by openings) having a length on plan not exceeding four times the thickness shall be classified as columns. Those having a length over four times the thickness and are caused by openings in wall shall be classified as walls.

Columns shall be measured from the top of footing/footing beams or floor surfaces to the underside of beams or slabs as the case maybe. Where the width of beams is less than the width of columns, the extra width at the junction shall be included in the beams.

The depth of the beams shall be measured from bottom of the slab to the bottom of the beams except in case of inverted beams where it shall be measured from top of slab to the top of beam. The cross-section of the beam shall be the actual cross-section below or above the slab.

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

14.2.2 Payment

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

14.3 Testing of Material

- a) A site laboratory shall be established by the Contractor for all the required testing of concrete, aggregates and other materials etc. All tests shall preferably be done at site. Only the test which are not possible to be carried out in the site laboratory shall be referred to the laboratory approved by the Engineer. All testing charges thereof shall be borne by the Contractor.

For testing of reinforcement steel bars, the samples shall be referred to the laboratory approved by the Engineer at the cost of the Contractor.

- b) Cement shall be tested as prescribed in ASTM C -150.
- c) Aggregates shall be tested as prescribed in British Standard BS 812 & 882. In addition fine aggregate shall be tested for organic impurities in conformance with ASTM Standard C.40.

14.4 Vapour Barrier

14.4.1 Measurement

Measurement of acceptably completed works of vapour barrier will be made on the basis of number of square feet provided and placed in position as shown on the Drawings or as directed by the Engineer.

14.4.2 Payment

Payment will be made for the acceptable measured quantity of vapour barrier on the basis of unit rate per square feet quoted in the Bill of Quantities and shall constitute full compensation for all the works related to the item.

Endo of Section 2300

SECTION - 3000
STRUCTURAL STEEL WORKS

- 1. SCOPE**
- 2. APPLICABLE CODES AND STANDARDS**
- 3. MATERIALS**
- 4. CONNECTIONS**
- 5. ALLOWABLE STRESSES**
- 6. SHOP DRAWINGS**
- 7. FABRICATION**
- 8. WELDER QUALIFICATIONS**
- 9. WELDERS IDENTIFICATION**
- 10. TEST ASSEMBLY**
- 11. SURFACE PREPARATION AND PAINTING**
- 12. INSPECTION AND TESTS**
- 13. ERECTION**
- 14. MEASUREMENT AND PAYMENT**

SECTIONS – 3000

STRUCTURAL STEEL WORKS

1.0 SCOPE

The work under this section consists of furnishing all material, labour, plant, equipment and appliances, fabricating, erecting, installing, testing, painting and all other items incidental to steel work for a complete job as shown on the drawings, specified herein and/or as directed by the Engineer.

2.0 APPLICABLE CODES AND STANDARDS

Latest edition of the following codes and standards are applicable to the work of this section:

AISC Specifications for the design, fabrication and erection of structural steel for buildings.

ANSI / AISC 360 Manual of steel construction, LRFD & ASD.

AISC 303 Code of Standard Practice, for Steel Buildings and Bridges.

AISC Specifications for structural joints using ASTM A325 or A490 bolts.

AISC Guide to shop painting of Structural Steel.

ASTM A6 Standard specifications for general requirements for rolled steel plates, shapes, sheets, piling and bars for structural use.

ASTM A36 Standard Specifications for Carbon Structural Steel.

ASTM A53 Standard Specifications for Pipe, Steel, Black & Hot Dipped, Zinc Coated, Welded and Seamless

ASTM A307 Carbon steel externally and internally threaded standard fasteners.

ASTM A325 High strength bolts for structural steel joints including suitable nuts and plain hardened washers.

ASTM A446 Specifications for steel sheet zinc coated (galvanized) by the hot dipped process.

ASTM A490 Quenched and tempered alloy steel bolts for structural steel joints.

ASTM A501 Hot formed welded and seamless carbon steel structural tubing.

ANSI / NAAMM Metal Bar Grating
MBG 531

ASTM A563 Carbon and alloy steel nuts.

ASTM A572 Standard Specifications for High - Strength Low - Alloy Columbium – Vanadium Structural Steel

ASTM E109 Dry powder magnetic particle inspection.

AWS D1.1 Specifications for welding of steel structures.

ANSI
B 18.2.2.1 Plain Washers.

SSPC – SP6 Steel structures painting council – surface preparation specifications.

3.0 **MATERIALS**

Except otherwise stated on the drawings, the material specifications shall conform to the following. Wherever necessary the Contractor may use equivalent alternative material subject to approval of the Engineer.

3.1 **Structural Steel**

- Structural steel shall conform to the requirements of ASTM A-36, or ASTM A-572.
- Steel pipes shall conform to the requirements of ASTM A 53 Class B, ASTM A501 or shall be made of plates spirally welded.
- All material shall be supplied chirpy V-Notch testing in accordance with ASTM A6, Supplementary Requirement S5.
- Grating shall conform to ANSI / NAAMM MBG 531.

3.2 **Welding**

Welding electrodes shall match the base metal and shall conform to the requirements of AWS D1.1 specifications.

3.3 **High Strength Bolts**

All shop connections, except as noted herein or on the drawings, shall be made with High Strength Bolts in friction type connections, or by welding.

High strength bolts, heavy hexagonal nuts and hardened washers shall conform to the requirements of ASTM A325. All field connections, except noted, shall be made with high strength bolts in friction type connection.

3.4 **Washers**

Washers shall conform to the requirements of ANSI B18.2.2.1 and shall be of structural grade steel appropriate for the type of bolts for which they are used. For oversized holes, the washers shall be large enough to cover the entire hole by at least 6mm (1/4 in.) or as directed by the Engineer.

3.5 **Studies**

Steel Studies Shear Connectors shall conform to the requirements of Structural Welding Code-Steel, AWS D1.1.

4.0 **CONNECTIONS**

All connections shall be designed and detailed for 75% of the effective capacity of the member. A minimum of two bolts or equivalent welding shall be used per connection.

Shop connection may be welded or bolted. Field connections shall be bolted unless noted otherwise on design drawings or approved by the engineer.

5.0 ALLOWABLE STRESSES

Allowable design stresses for structural steel members and their connections, including temporary bracings and shorings shall be in accordance with AISC Specifications.

6.0 SHOP DRAWINGS

- 6.1 Shop drawings shall be submitted by the Contractor, for structural steel works, for acceptance in accordance with the requirements or the Contract Documents.
- 6.2 Shop drawings furnished for this section shall conform to the best standards of the construction industry. Shop drawings shall be prepared by and under the supervision of competent engineering personnel. Prior to submittal, the Contractor shall check each shop drawing for compliance with the requirements of the Contract Documents.
- 6.3 Shop drawings shall include plans, elevations, sections and complete details to describe clearly, at an ample scale, all work to be provided. Drawings shall be accurately dimensioned and shall be noted clearly.
- 6.4 All connections shall be designed and detailed as, per sub-section 4 above, by the contractor on the shop drawings. Design calculations for connections shall be made as per AISC specifications and shall be submitted along with the shop drawings after checking and signing by the Contractor for approval of the Engineer.
- 6.5 The shop drawings shall include
- (i) An erection scheme, in suitable size, having the following information:
- Location of erection elements in respect of axis and Marks as well as picking points of these elements with respect to each other or with the existing steel or reinforced concrete structures.
 - Joints showing erection welding sizes and lengths, bolts diameter and numbers.
 - Chart showing list of assembling marks having columns such as Mark, Description, Quantity, Weight of each Mark, total weight and Remarks with grand total in the end.
 - Chart showing List of Erection Bolts, Nuts and Washers in tabulated form, detailing information such as size, quantity, weight and their grand totals.
 - Quality of materials.
 - Quality and type of welding electrodes.
 - Measures to be adopted against unscrewing of bolts.
 - Painting instructions.
 - Erection sequence.
 - References to relevant drawings.

- Except in special cases all scheme drawings shall be made in single fairly thick lines.
 - The recommended scale of erection scheme is 1:50, 1:100, 1:200, for joints 1:5, 1:10 or 1:20.
- (ii) Fabrication drawings in suitable size shall contain the following information:
- Each Shop Assembly (Mark) shall be drawn separately showing necessary lines, elevations, sections with reference to axis, center lines, location of holes, cleats, plates, lugs etc. fully dimensioned with part numbers.
 - Bolts and holes sizes.
 - Welding symbols and welded joints requirements, in accordance with AISC manual of steel construction and AWS specifications.
 - Geometrical Setting out dimensions necessary for the assembly of an element. Location and details of joints as calculated by the Contractor.
 - Instruction for welding, dimensions of weld, edge preparations methods of welding, and methods for control of distortions.
 - List of symbols for bolts and holes uses.
 - List of symbols for welds used.
 - Edge distance (general).
 - Welding sizes and lengths (general).
 - Standards and quality of materials.
 - Type and quality of welding electrodes.
 - Tests for welding.
 - Reference to related erection scheme drawings.
 - Reference to design and working drawings.
 - Part list.
 - Instructions for surface preparation, painting, primer and finish coats.

Recommended scales for fabrication drawings are preferably 1:10 or 1:20, and for joints and details 1:1, 1:2, or 1:5.

7.0 FABRICATION

The Contractor shall notify the Engineer about any problems or doubts/errors, if any, in the drawings for clarifications/rectification well in time to prevent any fabrication errors. Fabrication shall not be commenced until approval has been obtained from the Engineer.

7.1 **Straightening of Material**

Rolled material, before being worked upon shall be straightened within tolerances as per ASTM specifications A6. Straightening, necessarily shall be done by mechanical means or by the application of a limited amount of localized heat. The temperature of heated areas, as measured by approved methods, shall not exceed 1200 ° F.

7.2 **Cutting**

As far as practicable cutting shall be done by shearing. Oxygen cutting shall be done where shear cutting is not practicable and shall preferably be done by Machine. All edges shall be free from notches or burs. If necessary, the same shall be removed by grinding.

7.3 **Holes Punching/Drilling**

Holes shall be punched where thickness of the material is not greater than the diameter of bolt + 3mm (+ 1/8 in.). Where the thickness of the material is greater the holes shall either be drilled or sub-punched and reamed to size. The die for all sub-punched holes and the drill for all sub-drilled holes shall be at least 2mm smaller than the nominal diameter of the rivet or bolt.

7.4 **Welding**

7.4.1 All execution and inspection of welding shall be done in accordance with the provisions of the American Welding Society Specifications. No welding for piping/electrical supports shall be made transversely to any tension flanges or beams or columns.

7.4.2 Maximum and minimum size and lengths of fillet welds shall be in accordance with AISC specifications, or as mentions on drawing.

7.4.3 Surface to be welded shall be free from loose scale, slag, rust, grease, paint or any other foreign matter.

7.4.4 Butt welds shall be full penetration welds, unless otherwise specified and permitted.

7.4.5 Avoid the use of temporary welded attachments during fabrication as much as possible. After fabrication is completed, remove flush with the base material without encroaching on the minimum required base material thickness. After the surface has been restored, examine all areas from which temporary attachments have been removed by the same methods required for permanent fillet welds.

7.4.6 Do not begin structural welding until joint elements are tacked in intimate contact and adjusted to dimensions shown with allowance for any weld shrinkage that is expected. Weld heavy sections and those having a high degree of restraint with low hydrogen type electrodes. No member shall be spliced without approval.

7.4.7 For notch-toughness specified material, all weld metal, processes and preheat requirements shall be compatible to assure notch-tough composite weld metal.

7.4.8 Shop splices of webs and flanges in built-up girder shall be made before the webs and flanges are joined to each other.

7.5 Tolerances

Tolerances for Structural Steel be as per AISC Specifications unless noted otherwise.

8.0 WELDER QUALIFICATIONS

- 8.1 All welders contracted to perform work shall be required to show written evidence that they have been properly tested in compliance with the approved welding procedures.
- 8.2 Welders shall have been qualified in the proposed procedure by an established laboratory acceptable to the Engineer within the preceding 90 days.
- 8.3 All welders shall be qualified for the type of weldment, grade of steel, thickness of steel, welding process and welding position that they are employed to weld. Welders and welding operators that have not been performance qualified, for all material and thickness ranges used on the job, shall be restricted to welding only that portion of the work for which they are qualified.
- 8.4 Engineer reserves the right to have welders or welding operators requalified or removed from the job as he deems necessary during the progress of work. Engineer's decision regarding the qualifications of any welder shall be final.

9.0 WELDERS IDENTIFICATION

- 9.1 Each welder shall be assigned a unique identifying number or symbol that he shall use to identify all welding resulting from his skills.
- 9.2 Stenciled markings shall be applied within 40mm (1-5/8 in.) of the weld using low stress concentration dies. Written symbols are also acceptable.
- 9.3 A record shall be kept of these symbols by the Contractor. The records shall show welder's name, symbol assigned, procedures to which qualified, employment and test dates. This record shall be available to the Engineer's Representative at all times.

10.0 TEST ASSEMBLY

- 10.1 Fabricated components such as Beams Girders, Bracing, as and where required by planning, shall be test assembled in the shop prior to transportation to site.
- 10.2 Test assembly work and procedure should be planned during fabrication process.
- 10.3 Each test assembly shall be got inspected from the Engineer's Representative and shall be dismantled only after his approval in writing.

11.0 SURFACE PREPARATION AND PAINTING

Surface preparation and painting shall be in accordance with the provisions of the Code of Standard Practice of the American Institute of Steel Construction, Inc.

11.1 Surface Preparation

- a) All steel shall be cleaned free from loose scale, rust, burrs slag, etc. by means of sand blasting and/or other approved means as recommended by the manufacturer of paint.
- b) The sand used for this purpose shall conform to the type as specified in SSPC-SP.6. It should be free from earth, dust, clay and moisture. For this, the Contractor shall submit the gradation (no less than that passing through a 16 mesh screen U.S. sieve series) and source of sand along with the sample for approval by the Engineer prior to commencing the sand blasting operation.
- c) The size of sand particles, air pressure and size of the hose nozzle shall be correlated to give proper and acceptable surface.
- d) Material which is to be used for fabrication of components to be galvanized later on shall not be cleaned (See clause 11.3).

11.2 Painting

- a) After fabrication, assembly and surface preparation all assembled units shall be given two shop coats of epoxy primer and two coats of epoxy enamel paint in the fabrication shop.
- b) One final coat of epoxy enamel paint shall be applied after erection of all components.
- c) The thickness of each coat of paint shall be in accordance with the paint manufacturer's recommendation.
- d) All other requirements for the specified paint system shall be in accordance with the paint manufacturer's specifications/recommendations.
- e) The type of primer & paints to be applied shall be as specified in clause 11.2.1.
- f) The Contractor shall use the best quality of the type of paint specified and shall get the same approved by the Engineer.
- g) Steel work/Surfaces not to be painted
 - i) Steel work to be encased/embedded in concrete or surface in contact with concrete or grout shall not be painted, but shall be given a cement wash after surface preparation.
 - ii) Machined finished surfaces shall not be painted but shall be coated with rust preventive compound, approved by the Engineer immediately after finishing. Such surfaces shall also be protected with wooden pads or other suitable means for transportation. Unassembled pins, keys, and bolt thread shall be greased and wrapped with moisture resistant paper.
 - iii) Contact surfaces of connections using high strength bolts in friction type connections shall not be painted. Such surfaces of all components after fabrication shall be cleaned free of paint. No coating whatsoever then shall be applied to such surface. The surface roughness for high strength friction grip bolts is a

very important factor therefore components shall not be erected unless approved by the Engineer.

11.2.1 **Primer and Paint**

11.2.1.1 **Primer:**

Primer shall be epoxy primer of a proven quality. The type of primer to be used shall be approved by the Engineer.

11.2.1.2 **Paint:**

Paint shall be epoxy enamel of a proven quality. The type of paint to be used shall be approved by the Engineer.

11.3 **Galvanizing (Zinc Coating)**

Galvanizing, wherever specified, shall be applied in a manner and of a thickness and quality conforming to the requirements of ASTM A123 standard specifications for zinc (Hot galvanized) coating on products fabricated from rolled, pressed and forged steel shapes, plates, bars and strips.

Components shall be galvanized i.e. zinc coated after complete fabrication i.e. welding, drilling etc. the process shall consist of removal of rust and mill scale by pickling in hydrochloric acid or sulphuric acid followed by water wash and prefluxing in tanks containing zinc ammonium chloride and then fluxing with ammonium chloride. The fluxed components shall then be passed through a drying oven prior to immersion in a bath of virtually pure molten zinc.

12.0 **INSPECTION AND TESTS**

- 12.1 Manufacturer's Test Certificate for all material used shall be furnished by the Contractor for Engineer's scrutiny and approval.
- 12.2 Rolling tolerance of all shapes and profile according to AISC shall be in accordance with the provisions of ASTM A6 specifications. These shall be checked by the Contractor before commencing work and shall be rejected if found not within limits.
- 12.3 Materials shall be tested for conformance with the specified standards at an approved testing laboratory as and when directed by Engineer.
- 12.4 Contract surfaces of connections using high strength bolts in friction type connections shall be got inspected and approved from the Engineer before bolting.
- 12.5 All bolted connections shall be got inspected and approved from the Engineer for types, size, number of bolts and installation including tightening.
- 12.6 Inspection and Testing - Welding

12.6.1 **General**

Welding shall be inspected and tested by an approved testing laboratory during fabrication and erection of structural steel as follows:

The testing laboratory shall be responsible for conducting and interpreting the tests. It shall state in each report whether or not the test

specimens conform to all requirements of the Contract Document and shall specifically note any deviations therefrom.

Certify all welders and make 100 percent visual inspections and tests as follows:

- Record types and locations of all defects found in the welding work.
- The measures required and performed to correct such defects.

In addition to the requirements of AWS D 1.1, paragraph 8.15, each weld shall be visually free of slag, inclusions and porosity.

In addition to visual inspection of all welds magnetic particle, ultra-sonic and radiographic inspection shall be made of all welds as specified below. Magnetic particle tests shall be made on the root pass and finished weld.

The method of magnetic particle test shall be in accordance with ASTM E109. Any type of crack or zone of in-complete fusion or penetration shall not be acceptable.

Radiographic testing technique and standards of acceptance shall be in accordance with AWS D 1.1.

Ultra-sonic testing shall be performed in accordance with AWS D 1.1.

Welding inspection and test report showing evidence of the quality of welding shall be submitted by the Contractor. For each section of weld inspected and tested, furnish a report which clearly identifies the work, the welder's identification, the areas of inspections and test, the acceptability of the welds, and signature of the inspector or laboratory incharge. Each report shall be completed at the time of inspection or test. For radiographic examination, furnish a complete set of radiographs in addition to the reports. All inspection and testing shall be carried out in presence of the Engineer or his representative.

12.6.2 Test Methods

Use the following test methods as specified. The following list is in descending order. When a particular test method is specified for a joint and the method is impractical to use, use the next highest method practicable. The alternative method will be subject to approval, NDT procedures and techniques shall be in accordance with AWS D 1.1, section 6.7.

- a) Radiographic Method: In addition to the requirements of AWS D 1.1, comply with ASTM E94.
- b) Ultrasonic method.
- c) Magnetic particle method.
- d) Liquid Penetration Method: Visible-dye, solvent removable method only.

12.6.3 Members Designated for Tests

- a) Built – up Members:

Examine 100 percent of flange-to-flange and web-to-web welding by the radiographic method. For all web-to-flange and pipe column seam welding, examine ten percent of each welder's work as follows:

- Full penetration groove welds by the ultrasonic.
- fillet welds and partial penetration groove welds by the magnetic particle method.

b) Moment Connection Joints:

- Examine 100 percent of all flange-to-flange and web-to-web welding as follows:

Full penetration groove welds by the ultrasonic method or other method as designated by the Engineer.

Fillet welds and partial penetration groove welds by the magnetic particle method.

- For all web-to-flange welding, examine ten percent of each welder's work as follows:

Full penetration groove welds by the ultrasonic method or radiographic method as approved by the Engineer.

Fillet welds and partial penetration groove welds by the magnetic particle method.

c) Column Base Plates.

Examine 100% of all welding for connection of base plate to column.

d) Bracing Connections: Examine 100 percent of all welding for connection of diagonal bracing as follows:

- Groove welds by the ultrasonic method.
- Fillet welds by the magnetic particle method.

12.6.4 Requirement for ten percent Examination

- a) Examine a 300mm (12 in.) section of weld in each 3m (10 ft.) increment of each welder's work as directed by the Engineer. If the examination meets the acceptance standards of AWS D 1.1, the 3m (10 ft.) of weld represented will be accepted.
- b) if the examination fails to meet the acceptance standards, examine two additional 300mm (12 in.) sections in the 3m (10 ft.) increment as directed by the Engineer. If both of these examinations meet the acceptance standards, the 3m of weld represented will be accepted. Repair the defects detected in the first examination and re-examine.
- c) If one or both of the examinations fails to meet the acceptance standards, examine the remaining weld of the 3m (10 ft.) increment. Repair the areas that do not meet the acceptance standards and re-examine.

12.6.5 Repair and Re-Testing of Welds

Repair defective welds in accordance with AWS D 1.1, or replace the weld, and Re-test repaired and replaced welds by the same method and acceptance standard used to examine the original weld. In addition, when defective welds are found, the testing laboratory shall determine the cause of the defective welding and institute immediate corrective action.

All defective welding shall be repaired or replaced at the Contractor's expense.

12.7 Rejection

Neither the fact that the materials have been tested nor that the manufacturers test certificates have been furnished shall effect the liberty of the Engineer to reject material found not according to these specifications.

Materials or workmanship not in conformance with the provisions of these specifications shall be rejected at any time, after delivery or during the progress of the work or the completion and erection at site.

13.0 ERECTION

13.1 Bracing

All steel structures shall be carried up true and plumb within the limits defined in the AISC code of standard practice, and temporary bracing shall be introduced wherever necessary to take care of all construction loads to which the structure may be subjected including the equipment and the operation of the same. Such bracing shall be left in place as long as required for safety.

Wherever piles of materials, erection equipment and other loads are carried during erection, proper provision shall be made by the Contractor to take care of the stresses resulting from such loads.

13.2 Alignment

No permanent bolting or welding shall be done at site during erection until as much of the structure as will be stiffened thereby has been properly aligned and approved by the Engineer.

13.3 Joints Using High Strength Bolts

All structural joints using high strength bolts shall be executed and inspected in accordance with "AISC Specification for structural joints using ASTM A325 or A490 bolts". High strength bolts and nuts, loosened after tightening, shall be discarded and replaced with unused bolts and nuts.

14.0 MEASUREMENT AND PAYMENT

14.1 General

Except otherwise specified herein or elsewhere in the Contract Documents, no measurement and payment will be made for the under mentioned specified works related to the relevant items of the Bill of Quantities. The cost there of shall be deemed to have been included in the quoted unit rate of the respective items of the Bill of Quantities.

14.1.1 Nuts, bolts, screws, washers, weld metal and welding rods.

14.1.2 Testing of materials and welds, and repair of defects.

14.1.3 Surface preparation including cleaning with sand blasting.

14.1.4 Painting system including primer coats.

14.1.5 Galvanizing

14.1.6 Fabrication

14.1.7 Erection

14.2 **Structural Steel Works**

14.2.1 Measurement

Measurement of acceptably completed works of structural steel will be made on the basis of weight in kilogram, according to approved shop drawings, after verification at site to the satisfaction of the Engineer that the items fabricated, supplied and erected in position conform with the contract and approved shop drawings.

14.2.2 Payment

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

14.3 **MS Railing**

14.3.1 Measurement

Measurement of acceptably completed works of MS railing will be made on the basis of actual length in running meter/ running foot, according to approved shop drawings, after verification at site to the satisfaction of the Engineer that the items fabricated, supplied and erected in position conform with the contract and approved shop drawings.

14.3.2 Payment

Payment will be made for acceptable measured quantity of MS railing works on the basis of unit rate per running meter / running foot quoted in the respective items of Bill of Quantities and shall constitute full compensation for all the works related to the item.

14.4 **Steel Door**

14.4.1 Measurement

Measurement of acceptably completed works of Steel door will be made on the basis of net actual area in square meter / square foot, according to approved shop drawings, after verification at site to the satisfaction of the Engineer that the items fabricated, supplied and erected in position conform with the contract and approved shop drawings.

14.4.2 Payment

Payment will be made for acceptable measured quantity of Steel door on the basis of unit rate per square meter / square foot quoted in the respective items of Bill of Quantities and shall constitute full compensation for all the works related to the item.

14.5 **Steel Grating**

14.5.1 Measurement

Measurement of acceptably completed works of Steel grating will be made on the basis of number of gratings, according to approved shop drawings, after verification at site to the satisfaction of the Engineer that the items fabricated, supplied and erected in position conform with the contract and approved shop drawings.

14.5.2 Payment

Payment will be made for acceptable measured quantity of Steel grating on the basis of number of gratings quoted in the respective items of Bill of Quantities and shall constitute full compensation for all the works related to the item.

14.6 **Steel Gate**

14.4.1 Measurement

Measurement of acceptably completed works of Steel Gate will be made on the basis of number of Gates, according to approved shop drawings, after verification at site to the satisfaction of the Engineer that the items fabricated, supplied and erected in position conform with the contract and approved shop drawings.

14.4.2 Payment

Payment will be made for acceptable measured quantity of Steel Gate on the basis of number of Gates quoted in the respective items of Bill of Quantities and shall constitute full compensation for all the works related to the item.

*** End of Section 3000 ***

SECTION - 6700

PAINING

- 1. SCOPE**
- 2. APPLICABLE STANDARDS**
- 3. GENERAL**
- 4. MATERIALS**
- 5. DELIVERY, STORAGE AND CONTAINER SIZES**
- 6. SURFACE PREPARATION**
- 7. APPLICATION**
- 8. JOB CONDITIONS**
- 9. QUALITY ASSURANCE**
- 10. SCHEDULE OF MEASUREMENT OF PAINT AREA**
- 11. MEASUREMENT AND PAYMENT**

SECTION - 6700

PAINTING

1.0 SCOPE

The work under this section of the Specifications consists of furnishing all materials, plant, labour, equipment, appliances and performing all operations in any floor and at any height in connection with surface preparation, mixing, painting concrete works, gates, frames, walls, ceilings and all such surfaces as shown on the Drawings and/or as directed by the Engineer. The scope of this section of specification is covered with detailed specifications as laid down herein.

2.0 APPLICABLE STANDARDS

Latest editions of following British Standards are relevant to these specifications wherever applicable.

2.1 BSI (British Standards Institution)

- 245 Specification for mineral solvents (white spirits and related hydrocarbon solvents) for paints and other purposes.
- 2521 Lead-based priming paint for wood work.
- 2523 Lead based priming paint for iron and steel.
- 2569 Sprayed metal coatings.
- 4800 Paint colours for building purposes.
- CP.231 Painting of building.
- CP.3012 Cleaning and preparation of metal surfaces.

3.0 GENERAL

- 3.1 Except as otherwise specified, all painting shall be applied in conformity with BS CP 231 "Painting of Building" as applicable to the work.
- 3.2 The Contractor shall repair at his own expense all damaged or defective areas of shop-painted metal work and structural steel work. Metal surfaces against which concrete is to be placed will be furnished shop-painted and shall be cleaned prior to being embedded in concrete.
- 3.3 Except as otherwise specified all concrete and plastered surfaces are to be painted.
- 3.4 The Engineer will furnish a schedule of colours for each area and surface. All colours shall be mixed in accordance with the manufacturer's instructions.
- 3.5 Colours of priming coat (and body coat) where specified, shall be lighter than those of finish coat. The Engineer shall have unlimited choice of colours.
- 3.6 Samples of all colours, and finishes shall be prepared in advance of requirement so as not to delay work and shall be submitted to the Engineer for approval before any work is commenced. Any work done without such approval shall be redone to the Engineer's satisfaction, without additional expense to the Employer. Samples of each type of paint shall be on separate 12" x 12" x 1/8" tempered hard board panels. Manufacturer's colour chart shall be submitted for colour specifications and selection.

4.0 **MATERIALS**

- 4.1 All materials shall be acceptable, proven, first grade products and shall meet or exceed the minimum standards of reputable manufacturers as approved by the Engineer.
- 4.2 Colours shall be pure, non-fading pigments, mildew-proof sun-proof, finely ground in approved medium. Colours used on-plaster and concrete surfaces shall be lime-proof. All materials shall be subject to the Engineer's approval.
- 4.3 All synthetic enamel paints and primers for structural steel works, metal work and wood works will be the best available of its type and shall be approved by the Engineer prior to its procurement.
- 4.4 Approved quality Weather Shield/Weather Coat paint shall be used for painting the exteriors of the structures or other surfaces where specified on the drawings as directed by the Engineer.
- 4.5 The plastic emulsion paint, vinyl emulsion paint or similar as approved by the Engineer shall be used for interior surfaces.
- 4.6 Texture coating wherever specified shall be acrylic resin based coating composed of acrylic copolymers, natural quartz, natural marble chips, metallic oxides, antibacterial and antifungal additives, and expanders, foaming and setting agents and shall be applied in accordance with approved manufacturer's recommendations.
- 4.7 Only paints manufactured by ICI, Berger, Nippon Paints or approved equivalent shall be used in this Project.
- 4.8 All material shall be delivered to site in their original unbroken containers or packages & bear the manufacturer's name, label, brand & formula & will be mixed and applied in accordance with his directions.

5.0 **DELIVERY STORAGE AND CONTAINER SIZES**

Paints shall be delivered to the site in sealed containers, which plainly show the type of paint, colour (formula or specifications number) batch number, quantity, date of manufacture, name of manufacturer and instructions for use. Pigmented paints shall be supplied in containers not larger than 20 liters. All materials shall be stored under cover in a clean storage space, which should be accessible at all times to the Engineer. If storage is allowed inside the building, floors shall be kept clean and free from paint spillage.

6.0 **SURFACE PREPARATION**

- 6.1 All oil, grease, dirt, dust, loose mill scale and any other foreign substance shall be removed from the surface to be painted, polished and white washed by the use of a solvent and clean wiping material. Following the solvent cleaning, the surfaces shall be cleaned by scrapping, chipping, blasting, wire brushing or other effective means as approved by the Engineer.
- 6.2 In the event the surfaces become otherwise contaminated in the interval between cleaning and painting, re-cleaning will be done by the Contractor at no additional cost.
- 6.3 Surfaces of stainless steel, aluminum, bronze, and machined surfaces adjacent to metal work being cleaned or painted shall be protected by effective masking or other suitable means, during the cleaning and painting operations.
- 6.4 All the surfaces to be painted with approved quality paint shall be free from dust, dirt, fungus, lichen, algae etc. Oil paint, varnish and lime wash should always be removed by scraping and washing.

- 6.5 All surfaces to be bitumen painted shall be thoroughly cleaned of any accretion, dust, dirt etc. by scraping, wire-brushing or as directed by the Engineer. The surface shall be primed with a coat of asphalt oil used at the rate of not less than 0.50 pound per square foot.

No work in this section shall be allowed until all surfaces or conditions have been inspected and approved by the Engineer.

7.0 APPLICATION

- 7.1 All paint and coating materials shall be in a thoroughly mixed condition at the time of application. All work shall be done in a workman like manner, leaving the finished surface free from drips, ridges, waves, laps, and brush marks. All paints shall be applied under dry and dust free conditions. Unless approved by the Engineer paint shall not be applied when the temperature of the metal or of the surrounding air is below 7 degrees Centigrade. Surfaces shall be free from moisture at the time of painting.

All primary paint shall be applied by brushing. The first coat of paint shall be applied immediately after cleaning. When paint is applied by spraying, suitable measures shall be taken to prevent segregation of the paint in the container during painting operation.

Effective means shall be adopted for removing all free oil and moisture from the air supply lines of the spraying equipment. Each coat of paint shall be allowed to dry or harden thoroughly before the succeeding coat is applied. Surfaces to be painted that will be inaccessible after installation shall be completely painted prior to installation.

Coats of Weather Shield/Weather Coat paint shall be applied in accordance with the manufacturer's instructions or as directed by the Engineer.

Only as much material should be mixed as can be used up in one hour. Over-thinning will not be permitted. After the first coat the surfaces will be soaked evenly four or five times and the second coat shall be applied after leaving for at least overnight.

- 7.2 Where shown on Drawings all exterior finishes shall be painted with Weather Shield/weather coat paint or acrylic based textured coating (graffito) as shown on drawings in approved colours as per manufacturer's specifications. The number of coats shall be as shown on the drawings or as directed by the Engineer.

- 7.3 Plastic emulsion paint, vinyl emulsion paint or matt enamel paint of the approved make and shade shall be applied to surfaces as shown on Drawings as per manufacturer's instructions. The number of coat shall be as indicated on the Drawings or as directed by the Engineer.

8.0 JOB CONDITIONS

- 8.1 Observe manufacturer's recommended minimum and maximum temperature but do not apply paint or finish to any surface unless ambient temperature is 10 degree C or above and less than 43 degree C. No painting shall be done above 90% relative humidity.

- 8.2 Place drop cloths to adequately protect all finished work.

- 8.3 Remove and replace all items of finish hardware, device plates, accessories, lighting fixtures or other removable items.

- 8.4 In no case shall any finish hardware or other finished item that is already fitted into place be painted, unless otherwise specified.

9.0 **QUALITY ASSURANCE**

All paint for any one surface shall be top quality, of one manufacturer and approved by the Engineer. Deep tone accent colours shall be used and the unavailability of final coat colours may be the basis for rejecting materials for any one surface.

10.0 **SCHEDULE OF MEASUREMENT OF PAINT AREA:**

10.1 Irrespective of prime coats and number of paint coats applied to exposed painting surface area of column, walls, projections, ceilings, false ceilings and other surfaces (Except gates, doors windows and ventilators) shall be measured as per actual paint surface area for single time only and paid in accordance with quoted rate of Bill of Quantities.

11. **MEASUREMENT AND PAYMENT**

11.1 **General**

Except otherwise specified herein or elsewhere in Contract Documents, no measurement and payment will be made for the under mentioned specified works related to the relevant items of the Bill of Quantities. The cost thereof shall be deemed to have been included in the quoted unit rate of the respective items of Bill of Quantities.

The rates quoted by the Contractor in the Bill of Quantities shall include work to be executed under these specification in any floor and at any height except where otherwise specifically stated in the relevant item of Bill of Quantities and the Contractor shall not be entitled to any claim or claim any compensation on this account.

11.1.1 Preparatory works, including preparatory materials, scraping, scratching, sand blasting, cleaning, prime coating, priming, protection of finished works etc.

11.1.2 Polishing works, including preparatory materials, scraping, cleaning, sanding etc.

11.1.3 Before application of paint on existing surface the old paint surface shall be removed existing paint, filling of cracks, surface preparation and application of primer coat, if any.

11.2 **Painting / Acrylic based textured Coating**

11.2.1 Measurement

Measurement of acceptably completed respective type of painting works / Acrylic based textured coating (graffito) will be made on the basis of net actual length in square meter / square foot of the surface painted / coated as shown on the Drawings or as directed by the Engineer.

11.2.2 Payment

Payment will be made for acceptable measured quantity of respective type of painting / acrylic based textured coating (graffito) on the basis of unit rate per square meter / square foot quoted in the respective items of Bill of Quantities and shall constitute full compensation for all the works related to the item.

*** End of Section 6700 ***

ELECTRICAL WORKS

SECTION - 8001

GENERAL SPECIFICATIONS FOR ELECTRICAL WORKS

- 1.0 SCOPE OF WORK**
- 2.0 RULES & REGULATIONS**
- 3.0 AMBIENT CONDITIONS**
- 4.0 STANDARDS**
- 5.0 SYSTEM DATA**
- 6.0 EQUIPMENT**
- 7.0 DRAWINGS AND DATA TO BE FURNISHED BY THE CONTRACTOR**
- 8.0 MANUFACTURER'S INSTRUCTIONS**
- 9.0 GUARANTEE**
- 10.0 DANGER BOARDS WITH SIGNS, DESIGNATION AND SHOCK / FIRST AID CHARTS AND FIRE FIGHTING EQUIPMENT**
- 11.0 ASSOCIATED CIVIL WORKS**
- 12.0 INSTALLATION INSTRUCTIONS - GENERAL**
- 13.0 FACTORY TESTS**
- 14.0 TESTING - GENERAL**
- 15.0 APPENDICES TO BE FILLED IN BY THE BIDDER**
- 16.0 PAYMENT**

1.0 SCOPE OF WORK

The works related to the electrical system which is included in the Scope of this Contract as shown on the Drawings, stated in the Specifications and Bill of Quantities and explained in these Specifications. The works shall broadly include but not limited to the following:

- General Specifications for Electrical Works
- Low Voltage D.G. Set
- Indoor power Transformer
- H.T. Switchboards
- L.T Switchboards
- LT Distribution Boards
- Motor Control Centre
- Light Fixtures
- Low Tension Cables
- Wiring Accessories
- Conduits and Pipes
- Earthing
- Lightning Protection System
- Miscellaneous Items
- Structured Cabling Network
- Fire Alarm System
- Closed Circuit Television System
- Public Address System
- Cable Antenna TV System

The Contractor shall also be responsible to supply any other equipment not specifically mentioned in these Documents but which is necessary for proper operation of the works/system included in the scope of this Contract. The Contractor shall solely be responsible for ensuring proper functional requirements of different equipment. He shall also be responsible for furnishing any additional piece of equipment and for making modification in the equipment as desired and/or approved by the Engineer to achieve proper co-ordination with various equipment offered in the bid and also with those installed by others.

2.0 RULES & REGULATIONS

The entire electrical installation/work shall be carried out by licensed Contractor, authorised to undertake such work under the provisions of the Electricity Act 1910 and The Electricity Rules 1937 as adopted and modified upto date by the Government of Pakistan.

All works shall be carried out in accordance with the latest edition of the Regulations of the Electrical Equipment of Buildings issued by the Institute of Electrical Engineers-London, the Contract Documents, The Electricity Rules 1937 and bye-laws that are in force from time to time. Any discrepancy between these Specifications and any other rules and regulations shall be brought to the

notice of Engineer for his instructions and the discussion of the accepting/controlling shall be final and conclusive.

The Contractor shall be responsible for completing all formalities and submitting the test certificates as per prevailing rules and regulations, and shall have the installation passed by the Government Electric Inspector of that region. All requirements of the Electric Inspector and the WAPDA / MEPCO shall be complied with.

3.0 AMBIENT CONDITIONS

All material and equipment supplied and installed shall be designed, manufactured and tested to meet the following ambient conditions unless specifically stated otherwise for any material/ equipment.

Maximum indoors ambient temperature	:	45-Degree Celsius
Minimum indoors ambient temperature	:	Zero Degrees Celsius
Maximum outdoors-ambient temperature	:	50-Degree Celsius
Minimum outdoors-ambient temperature	:	Zero Degrees Celsius
Maximum Relative humidity	:	100 Percent
Maximum Altitude of project	:	220 meters above the mean sea level.

The atmospheric conditions are tropical and highly humid.

4.0 STANDARDS

The latest standards and codes of reputable organisations shall be applicable for the material and equipment specified herein and for installation work. Such organisations to be BSS, VDE, NFPA 99, NEC Article 517 etc. In case the Specifications laid down herein differ from those given in the standards, then the equivalent or better specifications shall govern. Wherever applicable the equipment shall also conform to the requirements of Pakistan Standard Institution (PSI).

Contractor shall maintain at the site office one copy of the standards / codes applicable to the works.

5.0 SYSTEM DATA

Unless otherwise specified elsewhere, all equipment and material shall be designed to operate satisfactorily with the following minimum requirements without any de-rating.

a) Voltage rating of equipment :	HT :	11 kV, 3 phase, +/- 10%
	LT :	400 V, 3 phase, +/- 10%
		230 V, 1 phase, +/- 10%

b) Frequency : 50Hz \pm 2Hz

In general, the electrical colour coding of switchgear cubicles, control panels, desks etc., shall be in accordance with the respective IEC Recommendations.

Live parts of electrical connections shall be colour coded according to IEC 446 as follows:

	Conductor Designation	Coding Alphanumeric	Colour
A.C. Network	Phase 1	L 1	red
	Phase 2	L 2	yellow
	Phase 3	L 3	blue
	Neutral	N	black
D.C. Network	Positive	L+	white
	Negative	L-	black
Earthing	Protective Earth	PE	green/yellow
	Earth	E	green/yellow

The colour coding for the secondary circuits of isolated power panel board is as follows:

Orange-Isolated Phase Conductor
Brown- Isolated Neutral Conductor
Green-Isolated Ground Conductor

Conductor insulation of secondary circuits of isolated power panel board shall be XLPE and PVC sheathed.

Control Cables

The Control Cables shall be manufactured according to specifications for L.T. Cables. The Control Cables shall be of multi-core, PVC insulated type withstanding without deterioration the conditions prevailing at the place of installation. The cross section of cable shall be as per the requirement of the system.

All the cores should be numbered and/or colour coded or otherwise properly identified. At-least 20% spare cores shall be provided in all Control Cables.

No separate payment is admissible for supplying, installing, testing and commissioning of control cables and is deemed to have been included in the BOQ rates of the respective equipment.

Distance in between power, communication and control cables shall be kept as per requirements laid down by NEC800, NFPA 70 and EN50174-2.

6.0 EQUIPMENT

6.1 IP Degree of Protection

The equipment shall have IP degree of protection as follows, unless mentioned other wise:

- IP 42 for indoor areas
- IP 54 for indoor damp areas
- IP 65 for outdoor areas

If properly rated equipment is not available, the Contractor shall provide field enclosures to attain the required IP degree of protection. If necessary cooling/exhaust fans and / or anti condensate heaters shall also be provided. No separate payment shall be made to attain the required IP degree of protection.

6.2 Identification & Labelling

All devices, meters, cabling, wiring and auxiliaries shall be properly labeled for identification. Labeling of equipment shall be done by means of flameproof material using indelible ink/markings. The labeling shall be such as to ensure uniformity and shall facilitate study of control diagrams/ drawings during operation and maintenance.

All labeling shall be of suitable size to be visible from the operating conditions/positions at site.

6.3 Lamp Test Facility

All equipment / switchboards, etc. shall be provided with common lamp test facility.

7.0 DRAWINGS AND DATA TO BE FURNISHED BY THE CONTRACTOR

The shop drawings, as-built drawings and/or technical data to be furnished by the Contractor for each electrical equipment, LT cable distribution layout & shall include, but not limited to the following:

- (a) Structural drawings showing foundations, RCC details dimensional plans,

elevation and sections on a suitable scale.

- (b) Electrical drawings showing:
- Line diagrams of Switchboards, Motor Control Centres, distribution boards and isolated power panels with detailed wiring diagrams, elevations/internal component layout and other standard details.
 - LT Cabling, Grounding/Earthing including all cable routing and support details.
 - Necessary execution details such as no. of cable/wires, size of conduits, cable routes, cable trays and cable trenches, etc.
 - Substation and Generator Room Equipment installation detail.
 - Manhole/Duct works.
- (c) Layouts of all LT cable routes with coordinates and levels.
- (d) Technical literature and manufacturer's characteristic data with the description of materials and weights of all equipment as instructed by the Engineer.

At least three (3) copies of the shop drawings and/or technical data of the equipment shall be submitted to the Engineer for checking and approval.

8.0 MANUFACTURER'S INSTRUCTIONS

The Contractor shall supply to the Engineer in properly bound form six (6) copies of manufacturer's instruction manuals for installation, testing, commissioning, operation and maintenance of the specified equipment including manuals of spare parts and tools of the equipment. At least two copies of the documents shall be submitted in original. The installation instructions shall be submitted 2 weeks prior to commencement of installation of each equipment, and operation and maintenance instruction at the time of commissioning. If the Contractor fails to provide the documents the Engineer shall withhold issuance of requisite certificates and deduct suitable amount from the payments to the Contractor.

9.0 GUARANTEE

The Contractor shall furnish written guarantee of the manufacturer or supplier with respect to satisfactory performance of each equipment. Guarantee shall be given for replacement and repair of part or whole of the equipment, which may be found defective in material or workmanship. The guarantee shall cover the duration of Maintenance Period as defined in the Conditions of Contract. This guarantee shall not relieve the Contractor of his obligations and he will be fully

responsible for the repair or replacement of any defective material in time, so as not to cause any undue delay in carrying out the repairs and/or replacements.

10.0 DANGER BOARDS WITH SIGNS, DESIGNATION AND SHOCK / FIRST AID CHARTS AND FIRE FIGHTING EQUIPMENT

Danger Boards having signs and designation of the room shall be installed on the external door of HT, LT, Power transformer, Low Voltage DG Set Rooms. Shock/First Aid Charts shall be installed in H.T, L.T and Low Voltage DG Set Rooms.

Potable fire fighting extinguisher suitable to control electrical fire shall be provided in H.T, L.T, Power Transformer and Low Voltage DG Set Rooms.

All the above items shall also be provided, wherever required to comply the requirements of the Pakistan Electricity Rules/Electric Inspector.

Laminated single line and adequate detail drawings on proper boards highlighting the main system features shall be displayed/ fixed in respective electrical and communication rooms.

11.0 ASSOCIATED CIVIL WORKS

Except where separately stated in the Bill of Quantities the cost of all civil works associated with any BOQ item of electrical works, such as excavation and back filling of earth, compaction of the earth, foundation pads, chiselling, making openings, etc. shall be included in the price quoted against respective items. No separate payment for such works will be made. Such works will also include repair of any damage to civil works caused by the Contractor during electrical installation.

12.0 INSTALLATION INSTRUCTIONS - GENERAL

The Contractor shall furnish all labour, materials, tools and equipment required to install, connect, test and commission all electrical equipment specified herein, whether or not such equipment is furnished by him or by others.

For all equipment to be installed by the Contractor, the Contractor shall supply and install all erection materials such as foundation bolts, washers, nuts, etc. as required and without any additional costs.

The Contractor shall set out the works himself as per Specifications and Drawings and shall properly position the equipment on specified foundation/location. In general, the manufacturer's instructions for installation shall be followed. Any defect or faulty operation of equipment due to the Contractor not following the manufacturer's instructions shall be corrected and repaired by the Contractor at his own cost.

For any deviation from the working drawings or specification that are deemed necessary by the Contractor due to site conditions, he shall submit the details and obtain the Engineer approval before starting such works.

13.0 FACTORY TESTS

All type and routine tests on Low Voltage D.G Set, Power Transformer, H.T Switchboards, LT Switchboards, Motor Control Centre, H.T Cables, LT Cables, and all other equipment shall be performed at the manufacturer's works in the presence of the Engineer or his Representative. Type tests may be waived off in case test certificates are submitted as certified by an Engineer approved standard laboratory of international repute; but merely producing the test type certificates will not relieve the manufacturer to carry out the required standard/routine tests.

The Contractor shall inform the Engineer about the date and time of test of each equipment at least two weeks in advance. This shall, however, be done after the Contractor has got the test procedures duly approved by the Engineer. The witnessing of test by the Engineer and the Employer shall not absolve the Contractor from his responsibility for the proper functioning of the equipment, and for furnishing the guarantees referred to in clause 9.0. All test results shall be supplied in quadruplicate. All expenses for carrying out the tests as incurred by the Engineer and the Employer to witness it shall be borne by the Contractor and deemed to have been included in the bid. Provision for at least two person's visit for Factory Acceptance Tests shall be made to include one representative each from the Employer and the Consultant/Engineer. The contractor shall undertake all formalities as may be required for the Engineer or his representative to enable him make the visit.

14.0 TESTING - GENERAL

14.1 Scope

Upon completion of the installation, the Contractor shall perform field tests on all equipment, materials and systems. All tests shall be conducted in the presence of the Engineer for the purpose of demonstrating equipment or system compliance with Specifications. The Contractor shall submit for Engineer's approval complete details of tests to be performed describing the procedure, test observations and expected results.

The Contractor shall furnish all tools, instruments, test equipment, materials, etc., and all qualified personnel required for the testing, setting and adjustment of all electrical equipment and material including putting the same into operation.

All tests shall be made with proper regard for the protection of the personnel and equipment and the Contractor shall be responsible for

adequate protection of all personnel and equipment during such tests. The cost of any damages or rectification work due to any accident during the tests shall be the sole responsibility of Contractor.

The Contractor shall record all test values of the tests made by him on all equipment. Four (4) copies of all test data and results certified by the Engineer shall be given to the Engineer for record purposes. These shall also include details of testing method, testing equipment, diagrams, etc.

The witnessing of any tests by the Engineer does not relieve the Contractor of his guarantees for materials, equipment and workmanship, or as any other obligations of Contract.

14.2 **Low Voltage D.G. Set**

Prior to the tests, the contractor shall submit manufacturer's recommended detailed description of the test procedures to be conducted for Engineer's approval.

The Contractor shall carry out full site load and no load tests in accordance with IEC, ISO or BS Specifications for site commissioning. The inspection and tests shall include but not be limited to:

Basic Tests:	Insulation Resistance Earth Continuity Earth Loop Impedance Polarity Phase Rotation Voltage and Frequency Starting System Protection Equipment
Battery:	Nominal Voltage Discharge Voltage Specific Gravity of Electrolyte Level of Electrolyte Charging System
Lubrication:	Check as required by manufacturer
Operational Check at Start-up	Oil Pressure Fuel Oil Leaks Operation of Safety Devices Operational Speed Automatic Control Instrument Check Exhaust Check Undue Vibration

Operational Check	Oil Pressure	
After one hour's run:	Oil Leaks	
	Cooling System	
	Oil Temperature	
Commissioning Test:	25% of full load	2 hrs.
	50% of full load	5 hrs.
	75% of full load	8 hrs.
	100% of full load	8 hrs.
	110% of full load	1 hr.

All commissioning and test results shall be recorded and compared with design data. A retest/commissioning shall take place if results are not satisfactory. All the tools, labour, POL, required for the testing and commissioning shall be provided by the Contractor at no extra cost. If required load is not available at site for testing the generators, the Contractor shall provide dummy load at site at no extra cost to the Employer. The correct functioning of the control equipment shall also be proved.

Battery Charger

Battery charger shall be static type and shall provide for both trickle and boost charging of the batteries when the engine is not in operation. The charger shall be of suitable capacity to fully recharge the completely discharged batteries within four hours at boost charge.

Control Panel

The Control Panel shall provide all the necessary control and monitoring devices of the Diesel Generating Sets. All the control and monitoring of the safety devices, alarms, protections, meters, lamps, etc. as mentioned in this Specifications and required as per good engineering practices for such an installation shall be provided in the Control Panel.

14.3 **Transformer Tests**

In addition to the insulation resistance test of the transformer, a polarity and phase rotation test shall also be made. Buchholz relay shall be tested for proper operation. Di-electric test shall be carried out on transformer oil prior to putting the same in operation.

14.4 **HT / LT Switchboards**

Each circuit breaker shall be operated electrically and mechanically. All interlocks and control circuits shall be checked for proper connections in accordance with the wiring diagrams given by the manufacturer.

The Contractor shall properly identify the phases of all switchgear and cables for connections to give proper phase sequence.

Trip circuits shall be checked for correct operation and rating of equipment served. The correct size and function of fuses, disconnect switches, number of interlocks, indicating lights, alarms and remote control devices shall be in accordance with approved manufacturer drawings. Nameplates shall be checked for proper designation of equipment served. Protective relays shall be tested and set at site prior to commissioning of the equipment.

14.5 **Insulation Resistance Test**

Insulation resistance test shall be made on all electrical equipment by using a meggar of 500 volts for circuits upto 250 volts and 1000 volt for circuits between 250 and 500 volts. For testing of 11 kV circuits, upto 5 kV meggar shall be used; the exact voltage shall be as advised by the equipment manufacturer unless otherwise advised by the Engineer.

The insulation resistance values of cables, transformer, switchgears, etc., shall be as per BSS, IEEE, NEC, ICEA and Pakistan Electricity Rules.

Before making connections at the ends of each cable run or joint between cables, the insulation resistance test of each cable section shall be made. H.T. cables shall be subjected to high voltage test as per recommendations of standard to which the cable is manufactured. Each conductor of a multi-core cable shall be tested individually with each of the other conductor of the group and also with earth. If insulation resistance test readings are found to be less than the specified minimum in any conductor, the entire cable shall be replaced and tests repeated on new cable. If cable joint is provided, then each cable section shall be tested, and joint made only after the tests have been made satisfactorily. Finally the completed cable length including the joints shall be tested.

The transformer and switchgears shall be given an insulation resistance measurement test after installation, but before any wiring is connected. Insulation tests shall be made between open contacts of circuit breakers, switches and between each phase and earth.

If the insulation resistance of the circuit under test is less than the specified value, the cause of the low reading shall be determined and removed. Corrective measures shall include dry-out procedure by means of heaters, if equipment is found to contain moisture. Where corrective measures are carried out, the insulation resistance readings shall be taken after the correction has been made and repeated twice at 12 hours interval. The maximum range for each reading in the three successive tests shall not exceed 20% of the average value. After all tests have been

made, the equipment shall be reconnected as required. Polarity test shall be made on single pole switching devices.

14.6 Earth Resistance Test

The Contractor shall make Earth resistance tests on the Earthing system, separating and reconnecting each earth connection.

If it is indicated that soil treatment or other corrective measures are required to lower the ground resistance values, the Engineer will determine the extent of such corrective measures.

The electrical resistance of the ECC together with the resistance of the Earthing leads measured from the connection with earth electrode to any other position in the complete installation shall not exceed one ohm.

Earth resistance test shall be performed as per Electrical Inspector's requirements. Where more than one earth electrodes are installed, the earth resistance test of each electrode shall be measured by means of resistance bridge instrument.

The complete lightning protection system shall be tested for continuity and earth resistance. The combined earth resistance at any point in the lightning protection system shall not exceed 10 ohms.

14.7 Completed Tests

After any equipment has been tested, checked for operation, etc., and is accepted by the Engineer the Contractor shall be responsible for the proper protection of that equipment so that subsequent testing of other equipment do not cause any damage to the already tested equipment.

14.8 Expenses

All expenses, i.e., travelling, boarding and lodging for carrying out the tests and witnessing by the Engineer shall be borne by the Contractor and are deemed to have been included in the BOQ rates of the respective equipment(s) by the Contractor.

14.9 Spare Parts

Contractor shall provide spare parts as identified in relevant appendix. The cost of each spare parts shall be carried over to relevant BOQ item and no extra payment shall be admissible in this regard.

14.10 Special Tools

Contractor shall provide special tools as indicated in Appendix-IV and as may be deemed essential for assembly, adjustment, dismantling, installation and maintenance reasons.

No separate payment shall be made for any special tools and cost shall be deemed to be included in the cost of the Contract.

15.0 APPENDICES TO BE FILLED IN BY THE BIDDER

The details regarding equipment manufacturers, deviations, etc., are to be furnished in the appendices attached with form of Bids, in accordance with the provisions of the clause "Requirements of Electrical Works" given in the instructions to Bidder, Volume - I.

16.0 PAYMENT

No separate payment shall be made for work involved within the scope of this section unless specifically stated in the Bill of Quantities or herein.

*** End of Section 8001 ***

SECTION - 8150

LIGHT FIXTURES

- 1.0 SCOPE OF WORK**
- 2.0 GENERAL**
- 3.0 APPLICABLE STANDARDS/CODES**
- 4.0 MATERIAL**
- 5.0 INSTALLATIONS**
- 6.0 MEASUREMENT AND PAYMENT**

1.0 SCOPE OF WORK

The work under this section consists of supplying, installing, testing and commissioning of all material and accessories of the complete Light fixtures as specified herein and/or shown on the Tender drawings and given in the Bill of Quantities.

The Contractor shall discuss the electrical layout with the Engineer and co-ordinate at Site with other services for exact locations and positions of the light fixtures.

The lighting fixtures with accessories shall also comply with the General Specifications for Electrical Works, Section-8001 and with other relevant provisions of the Tender Document.

2.0 GENERAL

The description of light fixtures is given in the bill of quantities, and stated on the drawings, and all relevant material is described in this Section. The determination of quality is based on certified photo-metric data covering the coefficient of utilisation, light distribution curves, construction material, shape, finish, operation, etc.

The Contractor shall submit at least two samples of each and every light fixture specified and obtain approval of the Engineer before purchasing. The quality and finishes of the local make light fixtures (if mentioned in BOQ) shall be same as that of standard manufacturer. The accessories such as ballast, LED drivers, lamps, ignitors, etc., for all type of light fixtures shall be of make as stated in list of approved manufacturers. Approved equivalent against those specified will be accepted if the specified one is/will not be available. For any substitution the Engineer's approval is necessary.

All fixtures shall be finished in standard colour schemes as mentioned in the manufacturer's catalogue for respective fixtures, unless specifically stated in the Specifications, Drawings or Bill of Quantities or directed by the Engineer.

3.0 APPLICABLE STANDARDS/CODES

The latest editions of the following standards/codes shall be applicable to the material specified within the scope of this section:

IEC 60598-2-1-	Particular requirement- Fixed general purpose luminaire
IEC 60598-2-2-	Electrical Insulation Class I
IEC 62471 -	Photo biological Safety of lamps and lamps system
IEC 62031 -	LED modules for general lighting – Safety specifications

IESNA LM80	-	Testing report for LED Chips with TM21 extrapolation graph
IEC 61048 & 61049	-	Capacitors for use in TL, HP mercury and LP sodium vapour discharge lamp circuits.
IEC 60598 & BS EN 60598	-	Luminaires
BS 2560	-	Exit Signs
ISO 7010	-	Signs for the purposes of accident prevention, Fire protection, health hazard information and Emergency evacuation.

4.0 MATERIAL

4.1 LED Essential/Waterproof Batten Light Fixture:

The Contractor shall furnish and install the complete LED Batten luminaires replacement for complete single conventional 1x18W TL-D/1x36W TL-D & double 2x36W TL-D fluorescent batten. The batten light fixtures shall be of proper rating as shown on the drawings. The LED batten light fixture shall be 1200mm long for 36/28watts and 600mm long for 14watts respectively as specified.

The luminaire shall be cool white, with colour rendering and light colour of 840 characteristics. The luminaire shall have such distribution to achieve general lighting application parameters. The luminaire shall use high efficiency diffuser to achieve at least 50% energy savings compared to conventional fluorescent and waterproof light fixture. The luminaire shall offer a composite system efficiency of at least 90 Lumen/Watt for Essential LED batten and at least 100 Lumen/Watt for Waterproof LED batten having an average lumen package of up to:

3800 lumens ($\pm 5\%$) in 36W replacement for 2x36W waterproof TL-D Batten

2700 lumens ($\pm 5\%$) in 28W replacement for 2x36W fluorescent TL-D Batten

1350 lumens ($\pm 5\%$) in 14W replacement for 1x36W fluorescent TL-D Batten

The LED luminaire shall be designed for lumen maintenance of L70 or 70% at the end of useful life at ambient temperature of 25 deg. C. The complete luminaire shall have a useful life of 40,000 burning hours. The luminaire shall be suitable for ambient temperature range of between -20 to +40 degrees Celsius. Third party IEC 60598 Test Report shall be measured/corrected for $T_a = 25$ degrees Celsius. The luminaire including the driver will include a warranty of at least 3 years against

manufacturing defects.

The housing of Essential LED Batten light fixture will include integrated heat sink and optical system. The housing will be made of galvanized sheet having white Powder coated & suitable for indoor & semi-indoor environment. The optical cover made up of Polycarbonate with UV Protected Shielding cover. The fixing mechanism will be through clip made of Stainless steel. Appropriate size bushed wire entry holes, fixing holes, and earth terminal shall be provided. The driver shall be integrated within the luminaire.

The housing of Waterproof LED Batten light fixture will be made of Polycarbonate & extrusion process & suitable for outdoor environment. The optical cover made up of Polycarbonate with UV Protected Shielding cover. The product shall be protected against harsh industry environments IP65 rating for dust & water protection. The luminaire shall have no harmful effect against water projected from any direction. The luminaire shall have impact protection classified as IK07 operating temperature. The driver shall be integrated with the luminaire in a separate gear compartment with similar Index protection.

The internal wiring of LED batten light fixtures shall be done with heat resistant wires at the manufacturer's factory. The internal wiring shall be clipped properly and heat resistant sleeves be provided on cables passing near driver. Connectors suitable for connecting 2.5 sq.mm cable conductors shall be provided for supply connections. An earth terminal for connection to 2.5-sq.mm cable conductor shall be provided.

The light fixtures shall be furnished with Perspex diffusing panels "040 opal acrylic" (minimum sheet thickness 3mm) etc. as specified on the drawings or in BOQ. The luminaire shall have provision of both surface, Suspended mounting with dimension compatible to conventional florescent fixture. Mounting Clips for installation must be available.

IP degree of Protection shall comply with the requirements laid down in Section 8001. Standard luminaries with manufacturer's recommended modifications, such as additional gasket, etc., shall be provided to attain required protection level.

4.2 LED Smart Panel Light Fixture:

The Contractor shall furnish and install the complete LED Panel luminaires as replacement for complete double conventional 2x36W TL-D fluorescent light fixture. The Smart Panel shall be of proper rating as shown on the drawings. The LED Panel shall have dimensions of 297 x 1197 x 75mm/595 x 595 x 75mm for 36 watts respectively as specified.

The luminaire shall be cool white, with colour rendering and light colour of

840 characteristics. The LED shall have a colour consistency preferably within 5 SDCM (standard deviation of colour matching) as defined by McAdam. The colour temperature variation should be restricted as per ANSI C78.377A with CCT variation limiting within 500K for nominal CCT of 4000K / 6500K.

The luminaire shall offer a composite system efficiency of at least 110 Lumen/Watt and a lumen package of up to 3,800 lumens ($\pm 5\%$) in 36W replacement for 2x36W conventional TL-D fluorescent fixture. The luminaire shall use high efficiency diffuser and reflector to achieve at least 50% energy savings compared to conventional fluorescent light fixture.

The system should be designed for fully hospital and office lighting & possess higher uniformity to have a smooth white light of high colour consistency & high system efficiency. For the better UGR control one, the luminaire optics should fully comply with hospital lighting norms with UGR value (Unified Glare Rating) < 25 . The beam angle of the optic should be around 140° .

The LED luminaire shall be designed for lumen maintenance of L70 or 70% at the end of useful life at ambient temperature of 25 deg. C. The complete luminaire shall have a useful life of 50,000 burning hours. The luminaire shall be suitable for ambient temperature range of between -20 to +40 degrees Celsius. Third party IEC60598 Test Report shall be measured/corrected for $T_a = 25$ degrees Celsius. The luminaire including the driver will include a warranty of at least 3 years against manufacturing defects.

The housing will include integrated heat sink and optical system. The housing will be made of electrogalvanized cold rolled steel sheet, pre-treated, painted and stove enamelled in white colour & the fixture will be provided with a plastic cover that is aesthetical for the hospital environment. The heat sink will design in such way to create better air-flow for better heat transfer. The light cover is made up of PMMA optics lens with PS diffuser & a suitable reflector for the best uniformity. Appropriate size bushed wire entry holes, fixing holes, and earth terminal shall be provided. The driver shall be integrated within the luminaire.

The internal wiring of LED batten light fixtures shall be done with heat resistant wires at the manufacturer's factory. The internal wiring shall be clipped properly and heat resistant sleeves be provided on cables passing near driver. Connectors suitable for connecting 2.5 sq.mm cable conductors shall be provided for supply connections. An earth terminal for connection to 2.5-sq.mm cable conductor shall be provided.

The luminaire shall have provision of recessed, surface or suspended mounting etc. as specified on the drawings or in BOQ with dimension

compatible to conventional florescent fixture. Mounting Clips for installation must be available. Shop drawings shall be submitted by contractor for approval of Engineer.

4.3 LED Down Light Fixtures

The Contractor shall furnish and install the surface mounted LED Downlight luminaires as replacement for single 1x18W or double conventional 2x18W PL-C incandescent/ compact fluorescent light fixture. The LED downlights shall be of proper rating as shown on the drawings. The LED Downlights shall have dimensions of 122/167/218mm dia. for 7/11.5/16 watts respectively as specified.

The luminaire shall be cool white, with colour rendering index greater than 80 and light colour of 840 characteristics. The Downlighter must be provided with a polycarbonate diffuser having high haze and light transmission for uniform light output. The beam angle must be in the ranges in between 95 to 100 degrees for better illumination.

The LED downlights shall have minimum system efficacy of at least 95 lm/W with 55% energy-saving as compared with conventional compact fluorescent lamp downlight fixtures and shall have a useful life of 50,000 burning hours for 70% lumen maintenance at the end of useful life at ambient temperature of 25 deg. C.

The downlighter shall have high reflectance white painted polycarbonate front element or High purity aluminium with high reflectance coated reflector along with tempered glass on the front cover. The housing will include integrated heat sink and optical system. The heat sink made with Die Cast Aluminum should be design in such way to create better air-flow for better heat transfer as furnished by the manufacturer or as specified in the drawings or BOQ. The fixing mechanism of recessed down light will be through spring fasteners.

Where surface mounted downlights are used, the housing will be made of Plastic and enclosed in white powder coated die-cast aluminium body for surface mounting installation. The body shall have fins as heat sink.

The types of fixtures with manufacturer's catalogue reference are given on the fixture schedule and in bill of quantities. Equivalent fixture may be acceptable provided that the contractor submits for review all necessary data indicating photometric curves to show that the fixture proposed are of the same type, construction and quality.

4.4 Compact Fluorescent Light Fixtures

The compact fluorescent light fixtures shall be as stated on drawings and bill of quantities. The light fixture shall be finished in standard colours

unless otherwise stated on drawings or directed by Engineer. All compact fluorescent light fixtures shall be of international standard and quality.

The lamps for compact fluorescent light fixtures shall be CFL type with normal or electronic control gear and shall be supplied and installed according to the wattage/type as indicated on drawings.

Weatherproof bulkhead incandescent/compact fluorescent light fixture shall comprise of plastic body and gasketed clear glass cover secured to the body by means of wing nuts/screws to give a weatherproof and watertight fit. The gasket shall be weather resistance type. The lamp holder shall be of bi-pin brass having porcelain outer ring or 2/4-pin base for compact fluorescent lamps with normal control gear as per requirements.

The glass shade of the light fixtures shall be opal white or clear as furnished by the manufacturer with the light fixture unless specified and free from any air bubbles or voids. The shade may be spherical, cylindrical, flattened bottom or any other shape as specified in the drawings or BOQ.

4.5 Exit Sign – Emergency Light Fixture

The exit sign emergency light fixture shall be maintained type with self contained, polycarbonate body, Gear Type and sealed nickel metal hydride batteries providing a backup of atleast 3 hours if not mentioned otherwise elsewhere. The light fixture shall have steel body powder coated in perma white finish, complete with screen printed acrylic legend panel. 2 X High Power 1W LED lamp and give 20 m route space. Legend panel shall be bottom entry for case of installation near walls. The legend pictogram shall be green colour and as approved by the Engineer.

4.6 LED Flood Light Fixture

The Contractor shall furnish and install the complete Boundary Wall luminaires maintaining avg. 30 lux for existing outdoor mixed traffic area, fully IP 66 with corrosion resistant die cast aluminum housing, silicon gas kit, thermally hardened glass complete with LED drivers, surge protection and all accessories/ components required for the proper operation of the system. The luminaries shall be fully flexible for future upgrades and easy replacements for maintenance purposes.

The luminaire shall have such distribution to achieve flood lighting application parameters. The luminaire shall offer a composite system efficiency of at least 100 Lumen/Watt and a lumen package of up to 13,000 for 120W+/-5W. The light fixture have three different optical beam angles Symmetric Wide Beam & Asymmetric Medium Beam & Narrow Beam optics according to application.

The LED light fixture should be designed for lumen maintenance of L70 or 70% at the end of useful life at ambient temperature of 45 °C and shall be capable to operate efficiently within the temperature limit of -40 °C to 50 °C. The complete light fixture should have useful life of 50,000 burning hours.

4.7 High Pressure Sodium Lamp

The high-pressure sodium SON-T plus lamp shall be of increased output tubular of rating 70 Watt and 400 watt as shown on the drawings. The base of the lamp shall be E40 with 6600 and 55,000 lumens output for 70 Watt and 400 Watt lamps respectively. The colour-rendering index Ra shall be 23. These lamps shall comply with EN60662.

4.8 Ballast for High Pressure Sodium Lamps

The ballast for high pressure Sodium lamps shall be polyester resin filled, totally encapsulated electromagnetic of copper / iron construction with leak proof body for use in combination with an external ignitor. The ballast shall fully comply with international Standards on Safety and performance, design compliance to IEC 60922/60923. The ballast shall be suitable for application in luminaries or poles under normal humid conditions. The ballast shall conform to the characteristics and wattage of the lamps. The wattage of lamp and ballast and a wiring diagram and other relevant data shall be printed on the body of the ballast. The power loss of the ballast shall not be more than 13.5-Watts for 70-Watts lamp and 28-Watts for 400-Watts lamp. The ballast shall be provided with insulated block of terminals for connecting up to 6 sq.mm cable with separate earth terminal.

4.9 Electronic Ignitors for High Pressure Sodium Lamps

The electronic ignitors for high-pressure sodium lamps shall be compact and light in weight with reliable and smooth starting behaviour. The ignitors shall be suitable for specified wattage of high-pressure sodium lamps and other requirements. The ignitors shall fully comply with IEC 60662 and EN 60926 regulations. The ignitors shall be provided with screw terminal / blocks and simple stud or screw mounting arrangement.

4.10 Capacitors for High Pressure Sodium Lamps

The capacitors for use in combination with high-pressure sodium lamp circuits shall be high-quality electrolytic capacitors for correction of power factor. The capacitors shall be of appropriate rating and type for the relevant lamp wattage. All capacitors shall be fitted with an internal discharge resistor, have a fuse fitted and be of self-healing type. Capacitor shall conform to IEC 61048/61049.

4.11 **Flood Light Lanterns**

The flood light lanterns shall have lamps of ratings specified in BOQ/ Drawings and shall be fully equipped with high grade reflector, corrosion proof housing with integral gear box, (Double insulation Class-II), compensated electrical control gear etc. complete with all internal wiring.

The flood light lanterns shall have non-corrosive, injection moulded, heat and UV-stabilized body, hammered aluminium reflector brightened and anodised, thermally – hardened 5 mm minimum glass, stainless steel snap-on hinged-clips, stainless steel protractor, hot dipped galvanized steel mounting brackets and stainless steel fixing accessories.

The housing shall be dust proof and jet proof to IP66, such that no internal cleaning shall be required.

4.12 **LED Street Light Fixture**

The road light fixture shall be an attractive modern appearance, high performance lantern suitable for 90W or 200W LED lamp as given in the BOQ/drawing.

Light fixture shall be provided with solid die cast aluminium housing, heat resistant silicon rubber gasket in optical LED compartment, DME type optic, tampered glass cover and shall be coated with powder of colour RAL 7040 ensuring no discoloration when exposed to UV light.

The light fixture shall be designed to receive power either from the battery or from the AC source. The light fixture shall have the following characteristics:

Voltage	=	220-240 VAC
Surge Protector	=	10 kV
Power Factor	>	0.9 (nominal power)

The light fixture shall have IP 66 protection to ensure long reliable performance and minimize maintenance requirement and an Impact resistance of IK 08 with insulation Class I. Use of chemical glue shall NOT be allowed to avoid probable breakdown of water-proof and dust-proof seal.

The light fixture should have a minimum color rendering index (Ra) of 70 + 5 and a color temperature of 4000K for maximum efficacy with an average output of at least 10,000 lumens for 90 Watt and 22,000 lumens for 200 Watt LED Fixture. The LED should have a color consistency within 5 SDCM (Standard Deviation of Color Matching). The color temperature variation of the LEDs should be restricted as per ANSI

C78.377A with CCT variation limiting within 500K for nominal CCT of 4000K.

The LED light fixture should be designed for lumen maintenance of L70 or 70% at the end of useful life at ambient temperature of 45 °C and shall be capable to operate efficiently within the temperature limit of -40 °C to 55 °C. The complete light fixture should have useful life of 50,000 burning hours.

The light fixture shall be fully compatible with future LED upgrades when they become available. It shall have a modular design to upgrade / replace with new LED modules or LED drivers at site conveniently with minimum effort. All electronic components/drivers shall be mounted on a separate removable gear tray. Light fixture housing shall have a tool less access by opening the cover.

The proposed LED road lighting light fixture shall be provided with in-built surge protection system to protect the electronic driver and LED system. Minimum surge protection rating is 10kV.

The housing shell, under the circuit board, shall be specially designed to ensure perfect contact between the circuit board and the light fixture housing for efficient heat dissipation. Only Metal Core PCBs shall be used to maximize heat transfer process and to offer reinforced electrical insulation via di-electric layer. The Metal Core PCB should be mounted on the housing using a highly efficient thermal interface material.

The optical LED compartment shall have a thermally hardened glass cover and high quality silicon gasket. The Glass cover will be tightly secured with the housing. The light fixture should have flexible optical system to achieve lighting parameters for required class of roads. The light fixture should offer a composite system efficiency of at least 100 lumen/Watt.

Specially designed lens system with unique inner and outer profile for high efficiency LED shall be provided to ensure maximum spacing between the poles and cover higher road widths. Multi layer optics design to ensure adequate luminance and luminance uniformity in the unlikely event of individual LED failure. The light fixture should offer choice of narrow, medium and wide beam light distribution.

The lamp position shall be adjustable to at least three positions to facilitate the changing of photometric distributions.. The photometric data of the lantern shall be authenticated by an Internationally Accredited Lighting Organisation.

Luminance level calculation with average luminance of the road surface, overall uniformity of road luminance, threshold increment, longitudinal

uniformity of road surface luminance and surround ratio achieved shall be submitted by the Contractor / manufacturer for verifying conformance to international lighting standards and approval of the Engineer.

4.13 LED Chips and Driver

The LED chip shall be from Cree / Nichia / Lumileds make or approved equivalent. The LED driver shall be designed to operate large array of high power LED's through current controlled output. The driver shall be suitable for operate up to 250VAC 50/60Hz mains supply. The LED driver shall have an efficiency of at least 90%. Fixed Output LED Driver (PSU) shall be integrated within each LED luminaire. The Driver compartment cavity and gear tray shall be designed with tool-less access for maintenance and replacement.

The light fixtures including the driver will include a warranty of at least 3 years against manufacturing defects. The cost of such provision will deemed to have been respective BOQ item of light fixture and no separate payment shall be admissible in this regard.

The LED driver shall fully conform to following specifications:-

- 1) BS-EN 61347-1 - General and safety requirements.
- 2) BS-EN 61347-2-13 - Particular requirements for DC or AC supplied electronic control gear for LED modules.
- 3) BS EN 55015: 2013 – Emission – Electrical lighting and similar equipment
- 4) BS EN 61547: 2009 – Immunity – Equipment for general lighting purpose
- 5) BS EN 61000-3-2: 2009 – Limits for harmonic currents emissions.
- 6) BS EN 61000-3-3: 2008 – Limits for voltage fluctuation and flicker.
- 7) BS EN 62493 – Assessment of lighting equipment related to human exposure to electromagnetic fields

5.0 INSTALLATION

5.1 General

The mounting heights of light fixtures are indicated on the drawings, and positions of fixtures are according to the mentioned scale.

The Contractor must ensure that the light fixtures are installed uniformly with respect to the dimensions of the area. Any modifications due to site conditions may be made with the approval of Engineer. All fixtures shall be carefully aligned before fixing in position.

The wiring between ceiling rose or terminal box and the fixture shall be carried out with 3-core 1.0 sq.mm and 1.5-sq.mm flexible copper

conductor PVC/PVC cable respectively for circuits protected by 10 amps and 15/20 amps MCBs. The wiring inside light fixture body shall be done with heat resistant cables or PVC insulated cable in heat resistant sleeves as approved by the Engineer.

Glasses, shades, reflectors, diffusers, etc., must be in a clear condition after installation. All light fixtures shall be earthed by an earth wire connected to the earth terminal in the fixture.

5.2 Street Light / Flood Light Fixture

The proposed street light fixture / flood light fixture shall be installed on the light pole/mast as per manufacturer's installation instructions. The road light fixture shall be properly levelled and the lamp adjusted to the appropriate position and all screws, bolts checked for tightness, etc. The light fixture shall be connected to the supply and earth at the proper terminals in the fixture.

5.3 Flood Light Lanterns

The flood light lanterns shall be installed on truss/G.I. bracket as per details shown on the drawing. Manufacturer's installation instructions shall be followed. The G.I. bracket shall be installed on column as shown on drawing. The exact location, rating and tilt/pan angles of light fixtures shall be finalized at site to suit the flood lighting requirements. Engineer's decision will be binding and final.

5.4 LED Batten / Panel Light Fixture:

LED Batten or Panel light fixtures on the surface of ceiling shall be installed with the back of the body flush with the ceiling surface, and in a manner so as to facilitate wiring. Nylon plugs and galvanized steel bolts or screws shall be used for fixing the light fixture to the ceiling. For light fixtures installation on false ceiling the installation method/detail shall be coordinated with ceiling design and submitted for approval of Engineer. Care shall be taken to prevent the weight of the fixture from being transferred to the false ceiling.

Pendant light fixtures shall have two holes in the top of each casing for supporting to the ceiling by a 3/4" dia. galvanized pipe or any other standard method as approved by the Engineer. Wiring from ceiling rose to the fixture shall be done through the pipe. Proper arrangements such as long threads with check nuts, etc. for minor adjustment in the mounting heights of the fixtures shall also be provided.

5.5 LED Down Light Fixture

LED downlight fixtures shall be installed on the surface of ceiling or wall by means of nylon plugs and galvanized steel screws, such that their

back finish flush with the surface for exposed conduits and flush with outlet box for concealed conduit system. Wherever convenient, screws for fixing light fixtures shall be screwed into the holes of the outlet box. The lights on false ceiling shall be installed in a manner as described for LED Panel light fixture.

6.0 MEASUREMENT AND PAYMENT

6.1 General

The Contractor's bid amount against each Bill of Quantities item as given below shall include supply, installation, testing, commissioning and completion for all work specified herein and/or shown on the Bidding Drawings related to the item.

6.2 LED Batten / LED Smart Panel / LED Downlight / LED Exit Light / CFL Bulkhead / LED or Conventional Flood Light/ LED Street Light Fixture

The Contractor's bid amount against each Bill of Quantities item as given below shall include supply, installation, testing, commissioning and completion for all work specified herein and/or shown on the Bidding Drawings related to the item.

6.2.1 Measurement

Measurement shall be made for each type of light fixture including all accessories acceptably supplied and installed by the Contractor as complete unit.

6.2.2 Payment

Payment shall be made for the number of units measured as provided above at the contract unit price each and constitute full compensation for supplying, installing, connecting, testing and completion of LED Battens / LED Smart Panel / LED Downlight / LED Exit Sign / compact fluorescent Bulkhead including all accessories such as capacitors , LED drivers, LED Chips, LED optics, connecting cables & connectors, suspension rods and pendent arrangement, GI pipe bracket, ceiling supports, internal wiring, nuts, bolts, screws, etc., as required and complete in all respects.

6.3 High Pressure Sodium Flood Light/ LED Flood Light / LED Street Light Fixture

The Contractor's bid amount against each Bill of Quantities item as given below shall include supply, installation, testing, commissioning and completion for all work specified herein and/or

shown on the Bidding Drawings related to the item.

6.3.1 Measurement

Measurement shall be made for each type of light fixture including all accessories acceptably supplied and installed by the Contractor as complete unit.

6.3.2 Payment

Payment shall be made for the number of units measured as provided above at the contract unit price each and constitute full compensation for supplying, installing, connecting, testing and completion of High Pressure Sodium Flood Light / LED Flood Light Fixtures/ LED Street lights including all accessories such as ballasts, capacitors, igniters, LED drivers, nuts, bolts, screws, etc., including PVC pipe, foundation etc., as required and complete in all respects.

*** End of Section 8150***

SECTION - 8220

WIRING ACCESSORIES

- 1.0 SCOPE OF WORK**
- 2.0 GENERAL**
- 3.0 APPLICABLE STANDARDS/CODES**
- 4.0 MATERIAL**
- 5.0 INSTALLATIONS**
- 6.0 MEASUREMENT AND PAYMENT**

1.0 SCOPE OF WORK

The work under this Section consists of supplying, installing, and commissioning of all material and services of the complete Wiring Accessories including switches, switch sockets, etc., as specified herein and/or shown on the Bidding drawings and stated in the Bill of Quantities.

The Contractor shall discuss the electrical layout with the Engineer and coordinate at Site with other services for exact location and position of all wiring accessories.

The wiring accessories such as switches, switch socket outlets, socket outlets and ceiling roses, etc. shall also comply with the General Specifications for Electrical Works Section 8001 and with other relevant provisions of the Bidding Documents.

2.0 GENERAL

The locations of the wiring accessories such as switches, sockets, etc. are tentatively shown on the drawings. The Contractor shall ensure the exact positions and locations of wiring accessories in coordination with other services drawings, as per site requirements and as directed by the Engineer. The Contractor shall be responsible for proper functioning of wiring accessories after installation and commissioning.

The description of switches, switch sockets, socket outlets etc. are given in the Bill of Quantities, stated as drawings and in this section. The Contractor shall submit sample of each and every item of wiring accessories for the approval of the Engineer.

3.0 APPLICABLE STANDARDS/CODES

The latest edition of following standards & codes shall be applicable for the materials specified within the scope of this section :

- | | | |
|---------|---|---------------------------------------------------------------------------------|
| BS 3676 | - | Switches for domestic and similar purposes. |
| BS 4343 | - | Industrial plugs, socket outlets and couplers for AC and DC supplies. |
| BS 2135 | - | Capacitors for radio interference suppression. |
| BS 67 | - | Ceiling roses. |
| BS 546 | - | 2-pole and earthing pin plugs, socket outlets and socket outlet adaptors. |
| BS 1362 | - | Specification for general purpose fuse links for domestic and similar purposes. |

- BS 1363
(Part 4-1995) - Specification for 13A fused connection units: switched and unswitched.
- BS 5733
(1995) - Specification for general requirements for electrical accessories.
- DIN EN
60669-1 - Switches for household and similar fixed electrical installations.

4.0 MATERIAL

4.1 Switches/Blank Face Plates

Switches for controlling light and fan points shall be single pole, rated for 10 Amps, 250 volts AC. The body of the switches shall be of thermoplastic with faceplate suitable for flush mounting and colour as approved by the Engineer. The switches shall be gang type having silver tipped contacts and shall operate with snap action.

Unless otherwise specified wherever switches control only the light points, these shall be plate type gang switches installed on common outlet boxes. Where only sheet steel back box is indicated on drawings, blank face plates shall be provided of same make and model as that of switches.

Where specified weather proof or metal front plates shall be used with single grid type switches. The plate shall be finished in specified colour or as otherwise directed by the Engineer.

The bell push switches shall be spring loaded type with the identification symbol embossed on it.

Two-way and intermediate switches shall be used to control lights from two or more different locations particularly in staircase as shown on the drawings.

4.2 13A Switch-Socket/Socket Outlets

Switch socket/Socket units shall be 3 pin, 13 A 250V, AC with faceplate of colour as approved by Engineer. The outlets shall be heavy-duty type suitable for mounting on sheet steel outlet box. The 13 Amps Switch socket/Socket outlets shall have sheltered live contacts and designed such that the earth pin of plug is engaged to socket earth before making of live contacts.

Where metal plate switches are installed, the switch socket units shall also be provided with front plate of similar design.

4.3 15A Socket Outlets

15 Amps Socket Outlets shall be 2 pin + earth, 250V AC socket outlets with faceplate of colour as approved by the Engineer by the Engineer.

The outlets shall be heavy-duty type suitable for mounting on sheet steel outlet box. The 15 Amps Socket Outlets shall be designed such that the earth pin of plug is engaged to socket earth prior to making contact to the live contacts.

4.4 32A Industrial Socket Outlet

The 32A, industrial socket outlet shall be weather proof conforming to the standard and requirements of relevant IEC codes.

The socket outlets shall be of heavy-duty type suitable for outdoor installation. The socket outlet shall be mounted on polycarbonate enclosure and have gasketed cover and window, captive cover screw type. All socket outlets shall be supplied with matching plugs.

4.5 64A Industrial Socket Outlet

The 16A, industrial socket outlet shall be weather proof conforming to the standard and requirements of relevant IEC codes.

The socket outlets shall be of heavy-duty type suitable for outdoor installation. The socket outlet shall be mounted on polycarbonate enclosure and have gasketed cover and window, captive cover screw type. All socket outlets shall be supplied with matching plugs.

4.6 Connection Unit

Connection Unit shall be used to supply to appliances where so specified or shown on drawings. (Air conditioner/Hand drier / Water heaters etc.).

It shall be rated for 20A, 250V AC or as shown on drawings/BOQ. The body shall be of thermoplastic material. Installation shall be surface/ concealed as required.

Face plate and colour to be as per approval of Engineer.

Connectors shall be of best quality (for Phase, Neutral and Earth) and suitable for the size of wiring.

The connection unit shall have the following features as per requirement in B.O.Q or as shown on drawing.

- 20 A Double Pole Switch
- Fuse – Rating as per requirement of appliance
- Neon Indication light
- Grommetted outlet on face plate suitable for flexible wiring connection to appliance

4.7 Ground Jack Module

Ground jack modules are used to make convenient ground connections for medical equipment of operation theaters. These unit contain ground jack receptacles and a ground bus. These modules shall be furnished with type #304 brushed stainless trim. These modules shall be provided with 30A twist-to-lock ground jacks, 1 No. copper ground bus bar 1/8" thick x 3/4" wide and lug suitable for 2.5 sq. mm. earth cable connection.

4.8 Fan Dimmers

The fan regulator/dimmer shall be made of low voltage electronic components with essential radio frequency compressor and shall be designed for smooth speed control/variation of fans. The regulators/dimmer and fan control switches shall be of same make and colour as that of the approved wiring accessories. The regulator/dimmer and fan-controlling switch shall preferably be mounted on same face plate. They shall be suitable for flush mounting on a sheet steel outlet back box.

4.9 Sheet Steel Back Boxes

The sheet steel boxes for installation of switches, fan dimmers, socket, outlets and blank face plates shall be made of 16 SWG sheet steel having appropriate dimensions. The box shall have suitable arrangement for receiving the conduit(s). An earth terminal shall be provided for connecting at least three earth wires of 4-sq.mm size. The outlet box shall be finished in powder-coated paint. The sheet steel back box shall be as approved by the Engineer.

4.10 Ceiling Roses

The ceiling roses shall be suitable for 5 amps 250 volts single-phase ac. It shall have white plastic moulded base plate and copper or brass terminals suitable for connecting at least two wires of 2.5 sq. mm size. The ceiling rose shall have a cover with cable inlet hole suitable for multicore PVC insulated and PVC sheathed cable.

5.0 INSTALLATION

5.1 General

The mounting heights of all wiring accessories are stated on the drawings. In case the mounting height is not mentioned, the instructions of the Engineer shall be obtained before fixing.

5.2 Wiring Accessories Installation

All wiring accessories such as Switches, Blank Face Plates, 13/15A Switch Socket, 32/64/125A Industrial Socket Outlet, Connection Units & ground jack modules shall be installed on 1.63 mm (16 SWG) thick sheet steel box recessed in wall/column/floor. The faceplate shall be fixed on sheet steel box by means of flat head galvanized or brass screws sunk in the faceplate so as to finish flush with the surface. Matching screw caps shall be installed on the opening for screw in faceplates.

The units installed in integrated bed head units shall be fitted with the parallel power tracks provided with the unit.

6.0 MEASUREMENT AND PAYMENT

6.1 General

The Contractor's bid amount against each Bill of Quantities item as given below shall include supply, installation, testing, commissioning and completion for all work specified herein and/or as shown on the Bidding Drawing related to the item.

6.2 13A Switch Socket/Socket Outlets, 15 Amps Switch Socket/Socket Outlets, 32/64/125A Industrial Socket Outlet Connection Units & Ground Jack Module

6.2.1 Measurement:

Measurement shall be made for the total number of each type of socket outlet complete with sheet steel back boxes, polycarbonate enclosure and all accessories acceptably supplied and installed by the Contractor as a complete unit.

6.2.2 Payment:

Payment shall be made for the total number of units measured, as provided above, at the Contract unit price each and shall constitute full compensation for supplying, installing, connecting,

testing and completion of each type and rating of outlet including screws, screw caps, sheet steel box, polycarbonate enclosure, nuts, bolts and other accessories as required.

*** End of Section 8220***

SECTION - 8230
CONDUITS AND PIPES

- 1.0 SCOPE**
- 2.0 GENERAL**
- 3.0 APPLICABLE STANDARD/CODES**
- 4.0 MATERIAL**
- 5.0 INSTALLATION**
- 6.0 MEASUREMENT AND PAYMENT**

SECTION - 8230

CONDUITS AND PIPES

1.0 SCOPE

The work under this section consists of supplying, installing and commissioning of all material and services of the complete Conduits and Pipes as specified herein and/or shown on Tender Drawings and stated in the Bill of Quantities.

The Contractor shall discuss the electrical layout with the Engineer and co-ordinate at Site with other services for exact route, location and position of the conduits and pipes.

The conduits and pipes with accessories shall also comply with the General Specifications for Electrical Works, Section-8001 and with other relevant provisions of the Tender Document.

2.0 GENERAL

The extent of works shown on the drawing does not indicate the exact position of conduits and pipes. The Contractor shall ensure exact location and route of conduit and pipes in coordination with other services drawings, as per site requirements and as directed by the Engineer.

The conduit system shall be continuous with manufacturer's recommended accessories.

The quality and material for the accessories of conduits and pipes such as sockets, end cap, elbows, bushings, bends, inspection/pull boxes, round boxes, etc., necessary for the complete installation shall be similar to that of conduits or pipes. All the accessories shall be supplied by the Contractor without any extra cost and deemed to have been included in the price of conduits/pipes.

Pull wire shall be laid in all empty conduits.

3.0 APPLICABLE STANDARD/CODES

The latest edition of the following standards and codes shall be applicable for the materials specified within the scope of this section:

- BS 31 - Steel conduits and fittings for Electrical Wiring.
- BS 4607 - Non-metallic conduits and fittings for electrical installations.
- BS 1387 - Galvanized Iron (GI) pipes and fittings.
- BS 3505 - uPVC pressure pipe and fittings.

4.0 MATERIAL

4.1 PVC Conduit and Accessories

The PVC conduits and accessories for lighting and power circuits shall be furnished by the Contractor as shown on the drawings or given in BOQ. The PVC bends shall have enlarged ends to receive conduit without any reduction in the internal diameter

at joint. Manufactured smooth bends shall be used where conduit changes direction. Bending of conduits by heating or otherwise will be allowed in special situations only for which the consent of the Engineer shall be required. The use of sharp 90 degree bends and tees will not be allowed for concealed wiring.

The round PVC junction boxes for ceiling light or fan points shall have minimum dimensions of 63 mm diameter and depth. The junction boxes for wall light points shall have minimum dimensions of 63 mm diameter and 38 mm deep. Round junction boxes shall be provided with one piece PVC cover plate fixed to the box by means of brass screws.

4.2 Inspection/Pull and Adaptable Boxes

Inspection/Pull boxes and adaptable boxes shall be provided in conduit runs wherever required to facilitate pulling operation. The drawings are diagrammatic and do not indicate the position and spacing of inspection/pull boxes or adaptable boxes. However, these shall be as per Engineer's approval.

4.3 uPVC Pipes and fittings

Unplasticized PVC pressure pipes and fittings shall conform to BS 3505:1968 and shall be of class-D (working pressure - 12 bars). The buried uPVC pipes should be able to withstand the external load acting upon it by continuous movements of heavy duty vehicles such as trucks, cranes, forklift etc. where pipe changes direction; manufacturer smooth bend shall be used.

Fittings and accessories for use with uPVC pressure pipes shall be of the same class and manufacture as the pipe and shall have the required shapes and dimensions of turned ends to fit the uPVC pressure pipes. uPVC pipes and accessories shall be suitable for jointing with rubber rings or solvent.

Bending of pipes by heating or otherwise will not be allowed. The use of sharp 90 degree bends and tees will not be allowed. The bends shall conform to same specifications as given for PVC conduits. For joining of pipe all precautions and procedures recommended by manufacturer shall be allowed.

Hard PVC or reinforced concrete pipe range spacers shall be used if there is more than one pipe running in parallel. The distance between range spacers shall be maximum 2 meters. Range spacers shall be prefabricated/precast and decay resistant.

Flexible pipes shall be used as deemed essential or as approved by the Engineer.

5.0 INSTALLATION

5.1 PVC Conduits and Accessories

5.1.1 Concealed Conduit

Where concealed conduit system is shown on drawings/ mentioned in BOQ, the conduit shall be installed concealed in roof, wall, column, etc. Conduits shall be laid under floor only where specifically stated. The entire conduit system shall be installed and checked before wiring is carried out. Any obstruction found shall be cleared before the installation of cable.

When concealed, the conduit shall have a minimum of 32mm cover of concrete measured from the top of conduit to finished surface. In the reinforced cement concrete (RCC) work the conduit shall be laid before pouring of concrete. Under no circumstances shall chases be made in the RCC structure for concealing conduit and accessories after pouring of concrete. The conduit shall be supported on top of bottom reinforcement of slab. All outlet boxes to be firmly supported and installed such that they finish flush with the soffit of slab or beam.

Where conduits have to be concealed in cement concrete (CC) work after concreting or in block masonry, chase shall be made with appropriate tools and shall not be made deeper than required. The conduit shall then be fixed firmly in the recess and covered with cement concrete mixture. The work of cutting in the cement concrete work or block masonry work shall be coordinated with the civil work. The Contractor shall obtain approval from the Engineer before starting chasing and cutting.

The termination of conduits at or near the equipment / switchboard is shown diagrammatically on the drawings. The exact locations of the termination shall be coordinated with the equipment/switchboard to be installed. Any extension of conduit to suit the site condition shall be made without any extra cost. Conduit ends pointing upwards or downwards shall be properly plugged in order to prevent the entry of foreign materials. All openings through which concrete may leak shall be carefully plugged in order to prevent the entry of foreign materials. All opening through which concrete may leak shall be carefully plugged and boxes shall be suitably protected against filling with concrete. At all terminations of conduit, sharp edges of conduit ends shall be prevented to avoid the cutting or damaging of wires or cables during pulling through the conduits.

Under floor conduit shall be installed at a minimum depth of 2 inch from the finished floor level or as shown on the drawings. The conduits shall be installed empty, before finishing of floor or in RCC work, with an 18 SWG steel wire drawn through the conduit for pulling cable. No conduits shall be laid under floor in bathroom.

5.1.2 Surface Conduits

The surface conduits shall be installed where shown on drawings mentioned in BOQ. The conduits shall be installed parallel or perpendicular to the surface of wall, structural members, ceiling, etc., by means of PVC saddles and clamps of approved design. The conduits shall be kept at least 150 mm away from parallel runs of flues, steam pipes and hot water pipes.

The saddles shall be installed on surface by means of nylon or wooden plugs and galvanized screws. Appropriate size of holes in structure shall be made by drilling; the thickness of saddles and clamps shall be at appropriate thickness and prime quality. The surface conduits shall be supported at maximum of one meter spacing along horizontal and vertical runs. The Contractor shall provide all accessories for complete installing of conduit system. The pull boxes, etc. as stated for concealed conduits shall also be applicable for surface conduit system.

5.2 uPVC Pipe and Fittings

uPVC pipes shall be installed as shown in the drawings. The depth of the pipe shall vary according to the conditions at site, and approval of Engineer shall be obtained prior to installation. In general the pipes shall be installed underground at the following depths measured from the top of the pipe.

- Under roads/pavement : 900 mm below finished surface.
- When crossing other services vertical/horizontal : 250/500 mm

The trench of required dimensions shall be excavated and the bottom of trench cleaned and leveled. A 100 mm bed of fine sand shall be provided over which the PVC pipes installed after proper alignment. Where two or more pipes are installed in the same trench the clearance between pipes shall not less than 50 mm. This shall be done by the provision of pipe range spacers as per Engineers approval. After lying of pipe the trench shall be backfilled with clean screened sand at least 100 mm above the top most pipes. The remaining portion of trench shall be backfilled with selected earth in layers well compacted.

After installation, the ends of the pipe shall be plugged with manufactured end cap impervious to water and chemicals. All joints shall be sealed adequately not only to prevent entry of foreign elements but also water tightness shall be ensured.

The installation of pipes shall be completed in all respects including its fixing at terminations, before cabling work is started. All sharp edges and burrs shall be removed by using reamer or any approved device. The pipe shall be through cleaned of dirt and dust from inside; the pipes shall be installed in proper co-ordination with other works.

The protective PVC pipe for cable entering building shall be installed so as to lead cable into the cable trench. The required number of pipes shall be fixed before completing the work in the plinth. If an opening is provided to the cable trench from outside, the required number of pipes shall be installed and part of the opening remained unutilized shall be properly packed and sealed using suitable packing material impervious to water and chemical to make it completely water-tight.

Spare pipes shall be provided with 5 mm dia rope pulled from end to end and plugged with manufactured end cap.

Flexible pipes of compatible material and size shall be used wherever deemed essential.

6.0 MEASUREMENT AND PAYMENT

6.1 General

The Contractors bid amount against each item of Bill of Quantities as given below shall include supply, installation, testing, commissioning and completion for all work specified herein and/or as shown on the Tender Drawings related to the item.

6.2 Conduits PVC / Pipes PVC and Accessories

6.2.1 Measurement

Measurement shall be made for the total running feet of each type and size of conduits / pipes and accessories acceptably supplied and installed by the Contractor according to specification and as shown on drawings.

6.2.2 Payment

Payment shall be made for the total running feet of each type and size of conduits or pipes measured as provided above at the contract unit price each and shall constitute full compensation for supplying, installing and completion of the laying of the conduits and pipes including all accessories related to the item.

No separate payments shall be made for the under mentioned specified work related to the supply and installation of conduit and pipe. The cost thereof shall be deemed to have been included in the quoted rates of above work.

- Excavation and backfilling.
- Dewatering during excavation and backfilling.
- Providing and filling of fine sand in trenches.
- Providing pipe range spacers.
- Providing flexible pipes and accessories, jointing material/compound, saddles, sockets, elbows, bend, junction boxes reducers, 16SWG GI pull wire for empty conduit, and 5 mm rope for empty pipe, soft metal bush, making threads and plugging of pipe with manufactured end cap etc. whether used or left spare.
- Compacted backfilling of trenches with specified material and disposal of surplus and rejected material.
- Watertight sealing of any unutilized opening to the buildings after installing the protective pipes entering the buildings.



UNITED NATIONS HIGH COMMISSIONER FOR REFUGEES (UNHCR)

RENOVATION/MAINTENANCE WORKS AT UNHCR OFFICE SECTOR G-4, ISLAMABAD

WALKWAY SHED & ABLUTION AREA SHED

TECHNICAL SPECIFICATIONS

AUGUST, 2022



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CIVIL WORKS

SECTION - 1100

EARTHWORKS

- 1. SCOPE OF WORK**
- 2. APPLICABLE STANDARDS**
- 3. GENERAL**
- 4. SITE PREPARATION**
- 5. CLASSIFICATION OF EXCAVATION**
- 6. EMBANKMENT CONSTRUCTION**
- 7. QUALITY CONTROL**
- 8. EARTH WORK FOR STRUCTURES, STORM WATER DRAINS & CULVERTS**
- 9. MEASUREMENT AND PAYMENT**

SECTION – 1100

EARTHWORKS

1.0 SCOPE OF WORK

The work under this section of the specifications consists of furnishing all plant, labour, equipment, appliances and materials and in performing all operations for excavation, backfilling, construction of embankments and disposal of unsuitable and surplus excavated material as required in accordance with this section of specifications, the applicable drawings and subject to terms and conditions of the Contract.

2.0 APPLICABLE STANDARDS

Materials, construction and testing shall comply with the following codes and standards:

ASTM C 136	Sieve or screen analysis of fine and coarse aggregate
ASTM D 422	Testing for Liquid Limit of Soils
ASTM D 424	Testing for Plastic Limit and Plasticity Index on Soils
ASTM D 596	Water Analyses
ASTM D1556	Density of soil in place by the sand cone method
ASTM D1557	Moisture-Density relation of soils using 4.5kg rammer and 457mm drop
ASTM D 2167	Density of soil in place by the Rubber-Balloon method
ASTM D 2216	Moisture content of soil
ASTM D 4253	Test method for maximum Index Density and unit weight of soils
ASTM D 4254	Test method for minimum Index Density and unit weight of soils
ASTM D 1883	CBR-California Bearing Ratio test

3.0 GENERAL

3.1 The Contractor shall acquaint himself with the nature of the ground, existing structures and subsurface materials (soil / rock) which will be encountered during excavation or earthworks. The Employer does not guarantee or warrant in any way that the materials to be found in the excavation will be similar in nature to that of any samples which may have been exhibited or indicated in the Report, Drawings or any other Contract Documents or to material obtained from boring or trial holes. The Contractor shall be deemed to have made local and independent inquiries as to, and shall take whole risk of the nature of the subsurface materials (soil / rock) to be excavated or penetrated and the Contractor shall not be entitled to receive an extra or additional payment nor to be relieved from any of his obligations by reasons of the nature of such ground and subsurface material.

3.2 The Contractor shall submit a detailed list of plant and equipment which he shall undertake to bring to the site and to carry out the work. The list shall satisfy the Engineer as to type, size and quantity. The Contractor shall place on the site of the work all of the equipment listed and all subsequent equipment required for approval of the detailed program of work and such equipment which may be directed by the Engineer. All equipment which is proposed to be used on the work shall be sufficient size and in such mechanical condition as to meet requirement of work and produce a satisfactory quality

of work. In no case shall the Contractor remove from the site the plant and equipment without the written approval of the Engineer. The Contractor shall supply all plant and equipment necessary for the construction of each phase of the work and it must be on site, inspected and approved by the Engineer. If after use of the equipment the Engineer determines that the work provided does not meet the Contract requirement, the equipment shall be changed and the deficient work shall be removed and corrected as directed by the Engineer.

- 3.3 All suitable materials from stripping of top soil and excavation shall be used unless otherwise declared unsuitable by the Engineer. The suitable material shall comply with the requirements as specified in the respective clauses for various items.
- 3.4 The Contractor shall jointly survey the area marked for pavements utilities, service lines, buildings or other structures or any area designated by the Engineer and prepare the survey drawings showing natural ground profile and cross-section and submit to the Engineer for approval prior to start of any earthwork operation.

All suitable material from excavations shall be transported to and placed in fill areas or stockpiled at locations designated by the Engineer. Materials from excavation and stripping shall be stockpiled separately.

Existing utilities which are to remain in service or to be relocated and to remain in service until relocation are to be determined by the Contractor. They shall be safeguarded and protected from damage.

If any existing service lines, utilities and utility structures which are to remain in service are uncovered or encountered during the operations, shall be safe guarded, protected from damage and supported as directed by the Engineer.

- 3.5 All excavations, cut and fills shall be constructed to the lines, levels and gradients specified with any necessary allowance for consolidation, settlement and drainage so that at the end of the Period of Maintenance the ground shall be at the required lines, levels and gradients. During the course of the Contract and during the Period of Maintenance any damage or defects in cuts and fills, in structures and other works, caused by slips, falls of wash-ins or any other ground movement due to the Contractor's negligence shall be made good by the contractor at his own cost.

4.0 **SITE PREPARATION**

- 4.1 The Contractor shall set out the works and shall be responsible for true and perfect setting out of the same and for correctness of the positions, levels, dimensions and alignments of all parts thereof. If at any time any error in this respect shall appear during the progress of the works, the Contractor shall at his own expense rectify such error, to the satisfaction of the Engineer.
- 4.2 The Contractor shall construct and maintain accurate bench marks so that the Lines and Levels can be easily checked by the Engineer.
- 4.3 The Contractor shall construct and maintain such temporary drains in addition to those shown on the plans, as will adequately drain areas during construction.
- 4.4 The Contractor shall perform a joint survey with the Engineer's Representative, of the area where earth work is required, plot the ground levels on the drawings and obtain approval from the Engineer before starting the earth work and shall supply a copy to the Employer duly checked, signed and authenticated by the Engineer before start of work.

5.0 CLASSIFICATION OF EXCAVATION

- 5.1 No classification shall be made of any material excavated / cut as to its class, nature, origin or condition. The excavation will be unclassified as being carried out in all kinds of subsurface material including soil and rock.

Blasting will be permitted only when proper precautions are taken for the safety of all persons, the work, and the property. All damage done to the work or property shall be repaired at the Contractor's expense. All operations of the Contractor in connection with the transportation, storage, and use of explosives shall conform to all state and local regulations and explosive manufacturers' instructions, with applicable approved permits reviewed by the Engineer. Any approval given, however, will not relieve the Contractor of his / her responsibility in blasting operations.

In each distinct blasting area, where pertinent factors affecting blast vibrations and their effects in the area remain the same, the Contractor shall submit a blasting plan of the initial blasts to the Engineer for approval. This plan must consist of holes size, depth, spacing, burden, type of explosive, type of delay sequence, maximum amount of explosive on any one delay period, depth of rock and depth of overburden if any. The maximum explosive charge weights per delay included in the plan shall not be increased without the approval of the Engineer.

The Contractor shall keep a record of each blast fired – its date, time and location; the amount of explosives used, maximum explosive charge weight per delay period, and, where necessary, seismograph records identified by instrument number and location.

The excavation wherever required will be carried out below ground water level by dewatering the area.

The Contractor shall build, maintain and operate all berms, channels, flumes, sumps and other temporary diversion and protective works needed to divert the surface water through or around the required excavation. All excavation shall be dewatered and kept free of standing water, water seeping from the sides and bottom of excavation above, the free level. The Contractor shall furnish, install, operate and maintain all drains, sumps, pumps and other equipment needed to dewater the excavation areas. Dewatering methods that cause a loss of fines from the bottom and slopes of the excavation will not be permitted.

Prior to commencement of the work, the Contractor shall furnish the Engineer for review and comments with complete plans and sketches for diverting surface water if any and dewatering of the required excavation.

Submission for review and comments of the required plans and sketches and any approval from Engineer shall not relieve the Contractor of any of his duties and obligations under the contract.

5.2 Tolerance

In those areas upon which a sub-base or base course is to be placed, the top of the subgrade shall be of such smoothness that when tested with a 4.8 m (15.75 ft.) straight edge applied parallel and at right angles to the centerline, it shall not show deviation in excess of 12 mm (1/2") or shall not be more than 16 mm (5/8") from line grade as established by grade hubs or pins. Any deviation in excess of these amounts shall be corrected by loosening, adding, or removing material; reshaping; and recompacting by sprinkling and rolling.

On graded strips (safety areas) intermediate and other designated areas, the surface shall be of such smoothness that it will not vary more than 30 mm (1-1/4") from true grade as established by grade hubs.

6.0 EMBANKMENT CONSTRUCTION

6.1 General

It shall consist of construction of select embankment for paved areas and common embankment for unpaved areas. Only approved material shall be used in the construction of embankments.

All embankment construction shall be made to the lines, levels, profiles and grades as shown on the drawings or established by the Engineer. During progress of the work it may be found necessary or desirable by the Engineer to vary the levels, elevations and grades from those shown on the drawings. The Contractor shall perform the embankment construction to the revised levels, elevation as established by the Engineer.

Where embankments are to be placed in water logged areas and which are inaccessible to heavy construction equipment, a working platform shall be first established, consisting of a blanket of fill material placed on the water logged area. The thickness of the working platform shall be about 0.5 metres (1.65 feet) unless directed otherwise by the Engineer and the width shall be that of the embankment. The placement and compaction of the working platform shall be performed by use of light equipment as directed by the Engineer. No density requirements are specified for the working platform, however, subsequent layers above shall be compacted to densities specified in the relevant items.

Benching of sufficient width for slope stability and movement of equipment and machinery shall be carried out for embankment formation in areas of steep slopes.

6.2 Select Embankment

The select embankment shall be constructed under all paved areas. The area shall be prepared (after stripping of top soil) by scarifying the surface to a minimum depth of 150 mm (6") and compacting it to densities mentioned in subsection 6.2.2.

6.2.1 Material

The suitable subsurface material obtained from excavation (except top soil) shall be used in the construction of select embankment. The material shall be A-4 or superior as per AASHTO soil classification. The soaked CBR of the material shall be equal to or greater than 6. In the top 30 cm (12 in.) the material shall be A-4 or superior and the $PI \leq 8$. When excavated material consists predominately of rock fragments of such size that the material cannot be placed in layers of the prescribed thickness without crushing, pulverizing or further breaking down the pieces, such material may be placed in layers not exceeding 60 cm (2 ft.) in thickness. Each layer shall be leveled and smoothed with suitable leveling equipment and by distribution of spalls and finer fragments of rock. These type lifts shall not be constructed above an elevation 150 cm (5 ft) below the finished sub-grade.

6.2.2 Formation of Embankment

Embankment shall be formed in successive horizontal layers of not more than 200 mm (8 in.) in loose depth for the full width of the cross-section, unless otherwise approved by the Engineer.

The material placed in layers and the sub-grade scarified shall be compacted to the density specified below:

Depth (cm) Below Subgrade Level		Percent of Max. dry Density as per ASTM D1557	
Cohesive Soil	Non-Cohesive Soil	Cohesive Soil	Non-Cohesive Soil
0 to 30	0 to 60	95%	100%
30 to 75	60 to 100	93%	95%
Over 75	Over 100	90%	90%

Sub-grade level is the surface on which the pavement structure will be placed.

The maximum density of sand (granular) material (if used) shall also be determined as per ASTM D4253. The higher of the two values obtained from ASTM D1557 and ASTM D4253 shall be used to check the relative compaction of the in place material.

The moisture content of the material should be controlled to within $\pm 2\%$ of the optimum moisture content. In order to achieve a uniform moisture content throughout, the wetting and drying of the material, and manipulation shall be required when deemed necessary. Also, the California Bearing Ratio test (ASTM D1883) may be conducted on soil if instructed by the Engineer.

The embankment formed by rock fragments of such size that the material can not be placed in layers of thickness prescribed without crushing, pulverizing or further breaking down the pieces, such material may be placed in layers not exceeding 60 cm (2 ft.) of loose measurement and compacted by vibrating roller with mass as specified hereunder:

Mass per metre width of Vibrating roll	Depth of fill layer	Number of passes of the roller on each layer
2300 – 2900 kg/m 1550-1950 lbs./ft.	40 cm 16 in.	5
2900 – 3600 kg/m 1950-2400 lbs./ft.	50 cm 20 in.	5
2600 – 4300 kg/m 1750-2900 lbs./ft.	60 cm 24 in.	5

The material shall be carefully placed in layer so that all larger stones will be well distributed and voids completely filled with smaller stones, small spall and soil to form a solid mass. After placing the rock material, surface shall be covered with fine material having thickness less than 20 cm (8 in.).

Material for each layer should be consolidated with heavy weight vibratory roller until settlement as checked between two consecutive passes of roller is less than 1% of the layer thickness. When rock to be incorporated in fill is composed largely of weak or friable material, the rock shall be reduced to a maximum size not exceeding 50% of the thickness of the layer being placed.

6.3 Common Embankment

6.3.1 Material

The area requiring common embankment, and other unpaved areas shall be constructed from the excavated soil and rock. The top soil obtained from stripping may be used at deeper level with the approval of the Engineer.

6.3.2 Formation of Embankment

Before placing and compacting the fill material the ground shall be scarified to a depth of 15 cm (6 in.) and compacted to a dry density of 90% as per laboratory compaction test method ASTM D1557. The moisture content of soil during compaction of scarified layer and successive layers shall be within $\pm 2\%$ of optimum moisture content before rolling to obtain the desired density results. The successive horizontal layers shall be formed in loose depth 200mm(8 in.) for the full width of the cross section unless otherwise approved by the Engineer. Each layer will be compacted to dry density of 90% as per laboratory compaction test method ASTM D 1557.

The layer thicknesses and compaction requirements shall be the same as specified under 'Select Embankment' for embankment formed by rock fragments.

No rock larger than 8 cm (3 in.) in any dimension shall be placed in top 30 cm (12 in.) of embankment unless allowed by the Engineer.

6.4 Tolerances

Select Embankment

The grade surface of each layer excluding final layer, shall be smooth and even and tolerance from required grade shall not be more than 19 mm (3/4 in.).

Common Embankment

The grade surface of each layer including the final layer, shall be smooth and even and tolerance from required grade shall not be more than 19 mm (3/4 in.).

6.5 Sub-grade Preparation in Cut

The area shall be prepared (after stripping of top soil) by scarifying the surface to a minimum of 150 mm (6 in.) and compacted to density mentioned in subsection 6.2.3. In case the material below Sub-grade level is not suitable (having PI >8) then a minimum of 30 cm (12 in.) of the soil shall be improved to PI ≤ 8.

The surface of the Sub-grade level (fill & cut) shall have the following tolerances:

- Plus : 0 mm (0 in.)
- Minus : 40 mm (1-5/8 in.)

7.0 QUALITY CONTROL

A testing program shall be submitted by the Contractor. Tests shall be performed by the Contractor to ensure compliance with the specifications as required. A copy of all test reports shall be submitted to the Engineer for approval. The test shall be performed in accordance with the following test procedures and frequency of testing.

Prior to construction of embankment, classification and compaction tests shall be carried out on stock-piled material obtained from stripping of top soil and excavated subsurface material (soil & rock). The tests shall be carried out as per ASTM 422, ASTM 424 and ASTM D 1557. A family of laboratory compaction curves as per ASTM D 1557 representing typical material shall be developed for the fill / backfill material.

The frequency of classification tests shall be for every 1000 cu.m / 35,000 Cft. of fill material. The Engineer may alter the frequency of testing depending on the type of material and variation encountered at site.

The field density tests shall be performed as per ASTM D 1556 or ASTM D 2167. The frequency of testing shall be as under:

Select Embankment

Area requiring 90% to 93% compaction – one test in every 500 m² / 5000 Sft. area in each layer

Area requiring 95% & 100% compaction – one test in every 300 m² / 3000 Sft. area in each layer

Common Embankment

Area requiring 90% compaction – one test in every 1000 m² / 10000 Sft. area

The average of four tests are required to be greater than the required compaction and not more than one test be 1.8% less than required percentage of compaction. This is for 100% compaction. For 95% to 90% compaction the following is required.

<u>%age Compaction</u>	<u>One test not less than</u>
95%	93.5%
90%	89.5%

8.0 EARTH WORK FOR STRUCTURES, STORM WATER DRAINS & CULVERTS

8.1 Excavation

Excavation, including dewatering where required, for building/related structures, culverts, storm water drains etc. shall conform to the elevations and dimensions as shown on the drawings and extend to a sufficient distance to permit placing and removal of concrete formwork or other construction.

When determined by the Engineer to be insufficiently firm, excavation bottoms shall be further excavated to reach firm ground or backfilled with suitable material and compacted to 95% of maximum dry density as per ASTM D-1557.

All excavations in foundations shall be taken as 150 mm (6 in.) above the final excavation elevations shown on the drawings and the last 150 mm (6 in.) shall be trimmed carefully to a smooth surface. Immediately after trimming to final elevation, a layer of blinding concrete shall be placed to thickness shown on the drawings.

8.2 Fill and Backfill for Structures, Storm Water Drains and Culverts:

8.2.1 After completion of foundation footings, foundation walls and other construction below the elevation of the final grades and prior to start of back-filling, forms shall be removed and the excavation shall be cleaned of trash and debris.

8.2.2 The backfilling/fill shall include filling under the floors where shown or required and around the foundations.

8.2.3 The backfilling/fill shall include loading, unloading transporting, placing, stacking, spread of earth, watering, rolling, ramming and compaction etc. complete as specified herein.

8.2.4 Filling in foundations shall be placed in 200mm (8 in.) loose layers and compacted at optimum moisture content by mechanical means or other means as approved by the Engineer.

8.2.5 Material for backfilling shall be as approved by the Engineer and compacted to produce insitu dry density not less than 95% of the maximum dry density as achieved by compaction test as per ASTM D-1557.

9.0 MEASUREMENT AND PAYMENT

9.1 General

Except otherwise specified herein or elsewhere in the Contract Documents, no measurement and payment will be made for the under mentioned items related to this section. The cost thereof shall be deemed to have been included in the quoted unit rates of the items of the Bill of Quantities under this section.

9.1.1 Timber shoring, planking, strutting and providing slope for upholding the sides of excavations.

- 9.1.2 Benching of sufficient width for slope stability and movement of equipment and machinery.
- 9.1.3 De-watering where required to keep the excavated areas dry for pavements, structures, storm water drains and culverts, during construction.
- 9.1.4 Rolling, leveling, watering and compaction for construction of embankments to required density.
- 9.1.5 Any fill with approved materials necessitated by over excavation due to fault or convenience of the Contractor.
- 9.1.6 Stock piling the excavated materials at approved location within Contract limits and transporting back suitable material to places requiring fill or backfill.
- 9.1.7 Scarifying & compaction of ground.
- 9.1.8 Transporting & backfill the suitable material from stripping.
- 9.1.9 Extra excavation involved in providing adequate working space around sides of foundations and culverts.
- 9.1.10 Rolling, leveling, watering and compacting the fill and backfill to required density.
- 9.1.11 All laboratory and field tests stipulated in these specifications
- 9.1.12 Preparation of sub-grade

9.2 **Embankment (Select)**

9.2.1. Measurement

Measurement of acceptably completed work of constructing select embankment will be made on basis of actual volume in cubic metre / cubic feet of compacted select embankment placed in position in accordance with the lines, levels and grade as shown on drawings or as directed by the Engineer.

9.2.2 Payment

Payment will be made for acceptable measured quantity of select embankment on the basis of unit rate per cubic metre / cubic feet quoted in the relevant items of Bills of Quantities and shall constitute full compensation for all the work related to the item.

9.3 **Embankment (Common)**

9.3.1 Measurement

Measurement of acceptably completed work of constructing common embankment will be made on basis of actual volume in cubic metre / cubic feet of compacted embankment placed in position in accordance with the lines, levels and grade as shown on drawings or as directed by the Engineer.

9.3.2 Payment

Payment will be made for acceptable measured quantity of common embankment on the basis of unit rate per cubic metre / cubic feet quoted in the relevant items of Bills of Quantities and shall constitute full compensation for all the work related to the item.

9.4 **Excavation**

9.4.1 Measurement

The quantities set out for excavation and its subsequent disposal shall be deemed to be the bulk quantity before excavating and no allowance shall be made for any subsequent variations in bulk or for any extra excavation.

Measurement of acceptably completed works of excavation for structures, storm water drains and culverts will be made on the basis of actual volume in cubic metre / cubic foot of earth material excavated to the line, level and grade as shown on the drawings or as directed by the Engineer. It shall be calculated / measured from pre-work levels and levels shown on the drawing.

9.4.2 Payment

Payment will be made for acceptable measured quantity of excavation on the basis of unit rate per cubic metre / cubic foot quoted in the Bills of Quantities and shall constitute full compensation for all the work related to this item.

9.5 **Backfill/Fill**

9.5.1 Measurement

Measurement of acceptably completed works of backfill/fills for structures, storm water drains and culverts will be made on the basis of actual volume in cubic metre / cubic foot of compacted backfill/fill provided and placed in position in accordance with the lines, levels and grade as shown on the drawings or as directed by the Engineer.

9.5.2 Payment

Payment will be made for acceptable measured quantities of backfill/fills for structures, storm water drains and culverts on the basis of unit rate per cubic metre / cubic foot quoted in the respective items of Bills of Quantities and shall constitute full compensation for all the works related to the item.

*** End of Section 1100 ***

SECTION - 2100

FORMWORK

1. **SCOPE**
2. **GENERAL**
3. **MATERIALS**
4. **DELIVERY AND STORAGE**
5. **WORKMANSHIP**
6. **MEASUREMENT & PAYMENT**

SECTION - 2100

FORMWORK

1.0 SCOPE

The work under this section of the Specifications consists of furnishing all plant, labour, equipment, appliances and materials and in performing all operations in connection with the supply and installation of formwork for the purpose of containing concrete during placement and consolidation in the required shape and form.

2.0 GENERAL

It shall be the responsibility of the Contractor to perform the work by engaging well trained and experienced staff.

3.0 MATERIALS

The Contractor shall use the following materials for different purposes as stated below:

3.1 Timber

Form framing, sheathing and shoring.

3.2 Plywood

Form sheathing and panels.

3.3 Steel

- Heavy forms and false work
- Column and joint forms
- Permanent forms
- Welding of permanent forms

3.4 Form Ties Anchors and Hangers

For securing formwork against placing loads and pressures.

3.5 Coatings

Facilitate form removal.

3.6 Steel Joints

For formwork support.

3.7 Steel frame shoring

For formwork support.

4.0 DELIVERY AND STORAGE

4.1 Delivery

The delivery of formwork components shall be made in a manner so as not to cause damage.

4.2 **Storage**

Form work should be stored, after cleaning and preparing for re-use, if used before in such a manner that access to all different component is available.

Form work component which can be affected by weathering shall be stored in appropriate building or under covers and shade.

5.0 **WORKMANSHIP**

- 5.1 Forms shall have sufficient strength to withstand the pressure resulting from placement and vibration of the concrete and shall have sufficient rigidity to maintain specified tolerances.

Where required details and locations of special forms to be used are set out on the drawings. The Engineer shall reject any formwork in any part of the work which has been constructed with a non- approved formwork. Approval of form work by the Engineer shall be one of these conditions to be fulfilled before concreting. The Engineer shall reject any concreting which may not conform to the approved model.

- 5.2 Earth cuts shall not be used as forms for vertical surfaces of reinforced concrete work unless required as such or permitted by the Engineer.

- 5.3 Formwork shall be of timber, steel, plywood, proprietary building boards and such special materials, as may be approved by the Engineer, which give the required finish and shape to the surface of concrete. Wooden formwork shall be free from loose knots and shall be well seasoned.

- 5.4 The formwork shall conform to the shape, lines and dimensions as shown on the plans, and be so constructed as to remain sufficiently rigid during the placing and compacting of the concrete, and shall be sufficiently tight to prevent loss of liquid from the concrete.

The design and engineering of the formwork, as well as its construction, shall be the responsibility of the Contractor. Where necessary, to maintain the specified tolerances, the formwork shall be cambered to compensate for anticipated deflections in the formwork due to the weight and pressure of the fresh concrete and due to construction loads.

The Contractor shall establish and maintain in an undisturbed condition and until final completion and acceptance of the project, sufficient control points and bench marks to be used as references for checking upon tolerances.

- 5.5 Requirements for 'facing materials' are given in the Section relevant to 'Finishing of Formed Surfaces.'

- 5.6 Where natural plywood-form-finish, grout-cleaned-finish, smooth-rubbed-finish, scrubbed-finish, or sand-floated-finish is required, forms shall be smooth (faced with plywood, liner sheets, or prefabricated panels) and true to line, in order that the surfaces produced will require little dressing to arrive at true surfaces. Where any as-cast finish is required, no dressing shall be permitted in the finishing operation.

- 5.7 Where as-cast surfaces, including natural plywood- form-finish are specified, the panels of material against which concrete is cast shall be orderly in arrangement, with joints between panels planned in approved relation to openings, building corners, and other architectural features.

- 5.8 Where panels for as-cast surfaces are separated by recessed or otherwise emphasized joints, the structural design of the forms shall provide for locating form ties, where possible, within the joints so that patches of tie holes will not fall within the panel areas.

- 5.9 Forms shall not be re-used if there is any evidence of surface wear and tear or defect which would impair the quality of the surface finish. Forms shall be thoroughly cleaned and properly coated before re-use.
- 5.10 Forms shall be sufficiently tight to prevent loss of mortar from the concrete. Unless otherwise specified in the Contract documents chamfer strips shall be placed in the corners of forms to produce beveled edges on permanently exposed surfaces. Interior corners on such surfaces and the edges of formed joints will not require beveling unless required by the Contract documents.
- 5.11 Positive means such as wedges or jacks for accurate adjustment and for proper removal of shores and struts shall be provided and all settlement shall be monitored during concrete placing operation. Forms shall be securely braced against lateral deflections.
- 5.12 Where concreting of thin members is required to be carried out within formwork of considerable depth, temporary openings in the sides of the formwork shall be provided where necessary to facilitate the placing and consolidation of concrete. Small temporary openings shall also be provided at the bottom of the formwork for columns, walls and deep beams to permit the cleaning out of debris and observation immediately before concrete is deposited.
- 5.13 Form ties shall be constructed so that the ends or end fasteners can be removed without causing appreciable spalling at the faces of the concrete. After the ends or end fasteners of form ties have been removed, the embedded portion of the ties shall terminate not less than twice the diameter or twice the minimum dimension of the tie from the formed faces of concrete to be permanently exposed to view and in no case shall this distance be less than 19mm (3/4 in.) when the formed face of the concrete is not to be permanently exposed to view from ties may be cut off flush with the formed surfaces.
- Through bolts may be permitted provided that they are greased to allow for easy withdrawal and the holes subsequently made good. Through bolts are not to be used on water-retaining structures.
- 5.14 At construction joints contact surface of the form sheathing for flush surfaces exposed to view shall overlap the hardened concrete in the previous placement by no less than 25mm (1 in.). The forms shall be held against the hardened concrete to prevent offsets or loss of mortar at the construction joint so as to maintain a true surface.
- 5.15 Wood forms for wall opening shall be constructed to facilitate loosening, if necessary, to counteract swelling of the forms.
- 5.16 Wedges used for final adjustment of the forms prior to concrete placement shall be fastened in position after the final check.
- 5.17 Formwork shall be so anchored to shores or to other supporting surfaces or members that upward or lateral movement of any part of the formwork system during concrete placement will not occur.
- 5.18 Runways or planks for moving labour and equipment shall be provided with struts or legs and shall be supported directly on the formwork or upon the structural member without resting on the reinforcing steel.
- 5.19 All surfaces of forms and embedded materials shall be cleaned of any accumulated mortar or grout from previous concreting and of all other foreign material before placing fresh concrete.
- 5.20 Forms shall be sufficiently tight to prevent leakage of grout or cement paste. Board forms having joints opened by shrinkage of the wood shall be removed and replaced. Plywood and other wood surfaces not subject to shrinkage shall be sealed against

absorption of moisture from the concrete by either (1) a field applied, approved form oil or sealer, or (2) a factory applied non-absorptive liner. When forms are coated to prevent bond with concrete, it shall be done prior to placing of the reinforcing steel. Excess coating material shall not be allowed to stand in puddles in the forms nor allowed to come in contact with the concrete against which fresh concrete will be placed. Care shall be taken that such approved composition is kept out of contact with the reinforcement. Where as-cast finishes are required, materials, which will impart a stain to the concrete, shall not be applied to the form surfaces. Where the finished surface is required to be painted, the material applied to form surfaces shall be compatible with the type of paint to be used.

- 5.21 For reinforced concrete, in no circumstances shall forms be struck until the concrete attains a strength of at least twice the stress to which the concrete may be exposed at the time of striking.

The strength referred to shall be that of concrete using the same cement and aggregates, with the same proportions, and cured under conditions of temperature and moisture similar to those obtaining in the work. Where possible, the formwork should be left for longer time as it would assist the curing.

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

- Walls, columns and vertical 48 hours or as may sides of beams decided by the Engineer.
- Side of slab (shores of 6 days props left under)
- Beams soffits (shores or 12 days props left under)
- Removal of shores or props to slabs:
 1. Spanning upto 4 metre (13 ft.) 10 days.
 2. Spanning over 4 metre (13 ft.) 16 days.
- Removal of shores or props to beams:
 1. Spanning upto 6 metre (20 ft.) 18 days.
 2. Spanning over 6 metre (20 ft.) 25 days.

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

The number of shores or props, their sizes and disposition shall be such as to be able to safely carry the full dead load of the slab and beams, as the case may be.

Proper allowance shall be made for the decrease in rate of hardening of concrete in cold weather and the above minimum duration must be increased when the mean daily temperature is below 20° C.

- 5.22 When repair of surface defects or finishing is required at an early age, forms shall be removed as soon as the concrete has hardened sufficiently to resist damage from removal operations.

- 5.23 Top forms on sloping surfaces of concrete shall be removed as soon as the concrete has attained sufficient stiffness to prevent sagging. Any needed repairs or treatment required on such sloping surfaces shall be performed at once and be followed by the specified curing.

- 5.24 Wood forms for wall openings shall be loosened as soon as this can be accomplished without damage to the concrete.
- 5.25 All formwork shall be removed without such shock or vibration as would damage the reinforced concrete. Before the top plank and struts are removed, the concrete surface shall be exposed where necessary in order to ascertain that the concrete has sufficiently hardened. Proper precautions shall be taken to allow for the decrease in the rate of hardening that occurs with all cement in the cold weather.
- 5.26 When reshoring or repropping is permitted or required, the operations shall be planned in advance and shall be subject to approval. While reshoring is underway no live loads shall be permitted on the new construction.

In no case during reshoring shall concrete in beams, slab, columns or any other structural member be subjected to combined dead and construction loads in excess of the load permitted by the Engineer for the developed concrete strength at the time of reshoring.

Reshores shall be placed as soon as practicable after stripping operations are complete but in no case later than the end of working day on which stripping occurs.

Reshores shall be tightened to carry their required loads without overstressing the construction. Reshores shall remain in place at least until tests representative of the concrete being supported have reached the strength specified in sub-clause 5.23 hereof.

- 5.27 Floors supporting props or shores under newly placed concrete shall have their original supporting props or shores left in place or shall be reshored. The reshoring system shall have a capacity sufficient to resist the anticipated loads and in all cases shall have a capacity equal to at least one half the capacity of the shoring system above. The reshores shall be located directly under a shore position above unless other locations are permitted.

The reshoring or re-propping shall extend over a sufficient number of storeys to distribute the weight of newly placed concrete, forms, and construction live loads in such a manner that the design superimposed loads of the floors supporting shores or props are not exceeded.

- 5.28 It is generally desirable to give forms for reinforced concrete an upward camber to ensure that the beams or slabs (specially cantilever slabs) do not have a sag when they have taken up their deflection, but this should not be done unless permitted by the Engineer.
- 5.29 No loads, other than man and light plant required in connection with the actual work in hand, shall be allowed on suspended floors until 28 days after concreting where ordinary Portland Cement is used and 14 days when rapid hardening Portland Cement is used.
- 5.30 Prior to placing concrete, all forms shall be inspected and all debris and extraneous matter removed. The form oil or release agent shall not react with concrete to affect the strength nor shall it give any colour. It shall be applied in such a manner as not to contaminate the reinforcement and other fixtures to be embedded in concrete.
- 5.31 Formwork for concrete pavement shall be made of steel of an approved section, with a base width of at least 200 millimeters (8 in.) and the depth shall be equal to the thickness of the pavement at the edge as shown on the plans. The forms shall be staked with steel stakes, and stakes shall be of a length approved by the Engineer. Each section of forms shall have a stake pocket at each end and at intervals of not more than 1.5 meters (5 ft.) between ends. The stake pockets shall have approved devices for locking the form to the steel stakes. Each section of forms shall be straight and free from bends and warps at all times. No section shall show a variation greater than 3 millimeter in 3 meters (1/8 inch in

10 ft.) from a true plane surface on the top of the form, and the inside face shall not vary more than 6 millimeters (1/4 in.) from a plane surface.

Before placing forms, the underlying base shall be to the required grade, and shall be firm and compact. The forms shall have full bearing upon the foundation throughout their length and shall be placed with exactness to the required grade and alignment of the edge of the finished pavement. They shall be so supported during the entire operation of placing, tamping and finishing the pavement that they will not deviate vertically at any time more than 3 millimeters (1/8 in.) from the proper elevation.

Forms shall not be removed for at least twelve (12) hours after the concrete has been placed. Forms shall be carefully removed in a manner to avoid damage to the pavement. Under no circumstances will the use of pry bars between the forms and the pavement be permitted. Pavement, which in the opinion of the Engineer, is damaged due to the careless removal of forms shall be repaired by the Contractor, as directed by the Engineer, at the Contractor's own expense. Forms shall be thoroughly cleaned and oiled each time they are used.

When pavement is placed adjoining existing concrete pavement upon which the finishing machine will travel, any irregularities in the old pavement shall be ground down to a true, uniform surface, of sufficient width to accommodate the wheels of the finishing equipment, if necessary to obtain proper smoothness of the pavement.

6.0 **MEASUREMENT AND PAYMENT**

Except otherwise specified in the Bill of Quantities no payment will be made for the works involved within the scope of this section of the specifications.

The cost thereof shall be deemed to have been included in the quoted unit rate of relevant concrete items of the Bills of Quantities.

*** End of Section 2100 ***

SECTION - 2200
REINFORCEMENT

- 1. SCOPE**
- 2. APPLICABLE STANDARDS**
- 3. MATERIALS**
- 4. COMPLIANCE WITH SPECIFICATIONS**
- 5. DELIVERY & STORAGE**
- 6. BAR BENDING SCHEDULES**
- 7. FABRICATING, BENDING AND PLACING**
- 8. MEASUREMENT & PAYMENT**

SECTION - 2200
REINFORCEMENT

1.0 SCOPE

The work under this section of specification consists of furnishing all plant, labour, equipment, appliances and materials and performing all operations in connection with the supply, transporting, cutting, bending and placing steel reinforcement, welded wire-fabric, dowels, tie-bars and assemblies in concrete structures, pavement or elsewhere, at any floor and at any height as shown in the drawings, as specified herein and as required by the site conditions or as directed by the Engineer.

2.0 APPLICABLE STANDARDS

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

Pakistan Standard

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

British Standard

B.S 4449	Carbon steel bars for reinforcement of concrete
B.S 4466	Specifications for Bending dimensions and scheduling of bars for the reinforcement of concrete.

ASTM Standard

A 185	Standard specification for welded steel wire fabric for concrete reinforcement.
A 305	Minimum requirement for the deformations of deformed steel bars for concrete reinforcement.
A 615	Standard specification for deformed and plain billet steel bars for concrete reinforcement.

ACI Codes

ACI 315	Details and Detailing of Concrete Reinforcement (ACI Publication SP-66)
ACI 318	Building Code Requirements for Reinforced Concrete.

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

3.0 **MATERIALS**

3.1 **Reinforcement**

3.1.1 General

Reinforcement shall be obtained only from manufacturers approved by the Engineer. Each consignment of reinforcement steel shall be accompanied by the manufacturer's certificate or shall refer to a previous certificate, if the consignment is from the same batch, showing that the reinforcement steel complies with the specified requirement. If such certificate is not made available, the Engineer may direct testing of different consignments of reinforcing steel at the Contractor's cost. Should the result of such tests show that the sample does not meet with the specifications the whole consignment shall be rejected and removed from the site at the Contractor's cost.

Reinforcement shall be free from all loose or flaky rust and mill scale or coating, and any other substance that would reduce or destroy the bond. Reduced section steel reinforcement shall not be used.

3.1.2 Reinforcing Steel

Unless otherwise specified, all plain reinforcing bars shall comply with the requirements of B.S 4449 for plain mild steel bars and shall have a minimum characteristic strength of 36,000 psi (250 MPa).

Unless otherwise specified, all deformed reinforcing bars shall comply with the requirements of ASTM A-615 for deformed hot rolled new stock billet steel bars and shall have a minimum characteristic strength of 40,000 psi (276 Mpa) and 60,000 psi (414 MPa), as shown on drawings.

3.1.3 Spacers and Supports

Spacers and supports shall be approved standard products of types best suited for the purpose.

3.1.4 Welding

The bars shall not be welded, unless prior approval of the Engineer is obtained in writing. If permitted, welding shall be done in accordance with relevant codes and standards taking all necessary precautions and safeguards. Where welding is unavoidable the Engineer may require substitution of the high strength deformed bars by plain round steel bars of lower grade, conforming to BS 4449, of equivalent strength.

4.0 **COMPLIANCE WITH SPECIFICATIONS**

The Contractor shall submit certificates of compliance from the manufacturer stating that the supplied reinforcement conforms to the Specifications. In addition, wherever and as directed by the Engineer, conformance of the supplied reinforcing bars with the specifications shall be demonstrated by the Contractor through laboratory tests, in accordance with the relevant standards.

5.0 DELIVERY & STORAGE

5.1 Delivery

Steel reinforcement bars shall be kept in bundles firmly secured and tagged. Each bar or bundle of bars shall be identified by marks as per relevant BS standard.

5.2 Storage

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

6.0 BAR BENDING SCHEDULES

The Contractor shall prepare bar bending schedules of all the reinforcing steel bars and shall obtain approval of the Engineer before proceeding with the work.

The Engineer's approval, however, will not relieve the Contractor of his responsibility in this regard.

7.0 FABRICATING, BENDING & PLACING

7.1 Reinforcement shall be accurately placed as shown in drawings and secured against displacement by using 16 gauge steel wire ties or suitable clips at intersections and supported from the formwork by using concrete, metal or plastic chains, spacers or hangers of an approved pattern. Where concrete blocks are used for ensuring the cover, they shall be made of mortar not leaner than one part of cement to two parts of sand.

Where the concrete surface will be exposed to the weather in the finished structure, the portions of all accessories in contact with the form work shall be galvanized or shall be made of plastic.

7.2 Bars used for concrete reinforcement shall be fabricated in accordance with the dimensions shown in the bar bending schedule approved by the Engineer.

7.3 The cutting tolerance for all reinforcing bars shall be 19 mm (3/4 in.).

7.4 Fabricating tolerance shall be as per ACI - 315.

7.5 Placing tolerances shall be as per ACI-318 & 317.

7.6 Bars may be moved as necessary to avoid interference with other reinforcing steel, conduits, or embedded items. If bars are moved more than one bar diameter or enough to exceed the above tolerances, the resulting arrangement of bars shall be subject to approval of Engineer.

7.7 Vertical bars in columns shall be offset at least one bar diameter at lapped splices. To ensure proper placement, templates shall be furnished for all columns dowels.

7.8 Reinforcement shall not be bent or straightened in a manner that will injure the material.

No bars shall be bent twice in the same place, nor shall they be straightened after bending.

Unless permitted, by Engineer, reinforcement shall not be bent after being partially embedded in hardened concrete.

- 7.9 No splice of reinforcement shall be made except as approved by the Engineer.
- 7.10 Welding of reinforcement shall not be done unless permitted and approved by the Engineer.
- 7.11 Exposed reinforcement intended for bonding with future extensions is to be effectively protected from corrosion. Protection is also to be provided to reinforcement partly built into concrete where the exposed part is to be built into later concrete.
- 7.12 No concreting is to be carried out until the reinforcement has been checked and approved by the Engineer.
- 7.13 All detailing shall be done as per ACI standards ACI-315, ACI-318 & ACI-350R, as and where required.
- 7.14 Standard or actual unit weight whichever is lesser shall be used for calculation of weights.

8.0 **MEASUREMENT & PAYMENT**

8.1 **General**

Except otherwise specified herein or elsewhere in the Contract Documents no measurement and payment will be made for the under mentioned specified works related to the relevant items of the Bills of Quantities. The cost thereof shall be deemed to have been included in the quoted unit rate of the respective items of the Bills of Quantities.

- 8.1.1 Providing and installing chairs, supports, hooks, spacers, binding wires, corrosion protection sleeves, wire cage or basket for tie bars and dowels and laps not shown on drawings including wastage and rolling margin.
- 8.1.2 Testing of mild steel, deformed steel, welded wire fabric, dowels, tie bars and assemblies.

8.2 **Reinforcing Bars.**

8.2.1 Measurement

Measurement for acceptably completed works of reinforcement shall be made by weight in metric ton according to bar bending schedules approved by the Engineer.

8.2.2 Payment

Payment will be made for acceptable measured quantity of reinforcement provided and placed in position on the basis of unit rate per metric ton quoted in the Bill of Quantities and shall constitute full compensation for all the works related to the item.

*** End of Section 2200 ***

SECTION – 2300

PLAIN AND REINFORCED CONCRETE

- 1. SCOPE**
- 2. GENERAL**
- 3. APPLICABLE STANDARDS**
- 4. MATERIALS**
- 5. NOMINAL CONCRETE MIXES**
- 6. TEST OF CONCRETE QUALITY**
- 7. FINISHING OF FORMED SURFACES**
- 8. REPAIR OF SURFACE DEFECTS**
- 9. CONCRETE CONSTRUCTION TOLERANCES**
- 10. ACCEPTANCE OF STRUCTURE**
- 11. PVC WATER STOP/HYDROFOIL**
- 12. NON SHRINK GROUT**
- 13. VAPOUR BARRIER**
- 14. MEASUREMENT AND PAYMENT**

SECTION 2300

PLAIN AND REINFORCED CONCRETE

1. SCOPE

The work under this section of the specification consists of furnishing all plant, labour, equipment, appliances and materials and in performing all operations in connection with the supply and installation of plain and reinforced concrete work complete in any floor and at any height as per drawings except where specifically stated in the relevant item of Bill of Quantities, in strict accordance with this section of the specifications and the applicable drawings, and subject to the terms and conditions of the Contract. The scope of this section of specification is covered with detailed specifications as laid down herein.

2. GENERAL

- 2.1 Full co-operation shall be given to trades like electrical, mechanical and other services.
- 2.2 Suitable templates or instructions or both shall be provided for setting out items not placed in the forms. Embedded items and other materials for mechanical and electrical operations shall have been completed, inspected, tested and approved before concrete is placed.
- 2.3 For special concrete finish and for special methods of construction (e.g. slip forms), formwork shop drawings shall be designed and prepared by the Contractor, at his own cost. Approval of shop drawings as well as that of actual samples of concrete finish shall be obtained before work is commenced.

3. APPLICABLE STANDARDS

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

3.1 Pakistan Standards

PS 177	Compaction factor test.
PS 232	Portland Cement (ordinary & rapid hardening).
PS 243	Natural aggregates for concrete.
PS 279	Abrasion of coarse aggregates by the use of Los Angeles machine.
PS 280	Determination of aggregates crushing value.
PS 281	Organic impurities in sand for concrete aggregates.
PS 282	Material finer than No. 200 B.S. test sieve in aggregates, method of test for.
PS 283	Soundness test for aggregates by the use of sodium sulphate or magnesium sulphate.
PS 284	Sampling aggregates for concrete.
PS 285	Sieve or screen analysis of fine and coarse aggregates.
PS 286	Description and classification of mineral aggregates.
PS 421	Sampling fresh concrete.
PS 422	Slump test for concrete.
PS 560	Making and curing concrete compression test specimen in the field.
PS 612	Sulphate-resistant Portland cement type 'A' and sampling fresh concrete in the laboratory.
PS 716	Mixing and sampling fresh concrete in the laboratory.
PS 717	Compacting factor test for concrete.
PS 746	Definitions and terminology of cements.
PS 849	Making and curing concrete compression test cubes.

3.2 ASTM (American Society for Testing and Materials)

B 370	Copper sheet and strip for building construction.
C 33	Concrete Aggregates.

C	40	Organic impurities in sand for concrete.
C	87	Effect of organic impurities in fine aggregates on of mortar.
C	88	Soundness of aggregates.
C	94	Ready mixed Concrete.
C	109	Compressive strength of hydraulic cement mortars.
C	117	Material finer than No.200 (0.075mm) sieve.
C	123	Light-weight pieces in aggregates.
C	125	Concrete and concrete aggregates.
C	127	Specific gravity and absorption of coarse aggregate.
C	128	Specific gravity and absorption of fine aggregate.
C	131	Resistance to abrasion of small size coarse aggregates.
C	136	Sieve or screen analysis of fine and coarse aggregate.
C	142	Clay lumps and friable particles in aggregates.
C	143	Slump of Portland Cement Concrete.
C	144	Aggregate for masonry mortar.
C	150	Portland Cement.
C	156	Water retention by concrete curing material
C	171	Sheet material for curing concrete.
C	185	Air content or hydraulic cement mortar.
C	188	Density of hydraulic cement.
C	191	Time of setting of hydraulic cement by vicat needle.
C	260	Air entraining admixtures for concrete.
C	289	Potential reactivity of aggregate.
C	309	Liquid membrane-forming compounds for curing concrete.
C	330	Lightweight aggregates for structural concrete.
C	331	Lightweight aggregates for concrete masonry.
C	332	Lightweight aggregates for insulating concrete.
C	494	Chemical admixtures for concrete.
C	535	Resistance to abrasion of large size coarse aggregates.
C	567	Unit weight of structural lightweight concrete.
D	75	Aggregate sampling.
D	994	Preformed expansion joint filler for concrete.
D	1190	Concrete joint sealer (hot poured elastic type).
D	1751	Preformed expansion joint filler for concrete paving and structural construction.
D	1752	Preformed sponge rubber and cork expansion joint fillers for concrete paving and structural construction.
D	1850	Concrete joint sealer (cold application type).
E	11	Wire cloth sleeves for testing purposes.
E	96	Water vapour transmission of materials in sheet form.
E	154	Materials for use as vapour barrier under concrete slabs.
E	337	Relative humidity by wet and dry bulk psychrometer.

3.3 ACI (American Concrete Institute)

211.1	Recommended practice for selecting proportions for normal and heavy weight concrete.
214	Recommended practice for evaluation of strength test result of concrete
301	Specifications for structural concrete for buildings.
304	Recommended practice for measuring, mixing, transporting and placing concrete.
305	Hot weather concreting.
308	Recommended practice for curing concrete.
309	Recommended practice for consolidation of concrete.
318	Building code requirements for reinforced concrete.
347	Recommended practice for concrete formwork.
512	Precast structural concrete in building.
517	Low pressure steam curing.
533	Fabrication, handling and erection of Precast concrete wall panels.

3.4 British Standards

BS 12	Portland cement, ordinary and rapid hardening.
BS 410	Test Sieves.
BS 812	Methods for the sampling and testing of mineral aggregates, sands and fillers.
BS 882	Coarse and fine aggregates from natural sources.
BS 1305	Batch Mixer.
BS 1881	Methods of testing and sampling concrete.
BS 3148	Tests for water for making concrete.
BS 3837	Expanded polystyrene boards.
BS 5328	Structural Concrete.,
BS 3869	Rigid expanded polyvinyl chloride for thermal insulation.
BS 3927	Phenolic foam materials for thermal insulation and building applications.
BS 4027	Sulphate-resisting Portland cement.
BS 8110	Structural use of concrete.
CP 114	Structural use of reinforced concrete in buildings.
CP 116	Structural use of Precast concrete.
CP 5337	The structural use of concrete for retaining aqueous liquids.

In addition, the latest editions of other Pakistan and British Standards, American Concrete Institute Standards, American Society for Testing and Materials Standards and other Standards as may be specified by the Engineer for special Materials and Construction are also relevant.

4. MATERIALS

4.1 Aggregates

- 4.1.1 The sources of supply of all fine and coarse aggregates shall be subject to the approval of the Engineer.
- 4.1.2 All fine and coarse aggregates shall be clean and free from clay, loam, silt and other deleterious matter. If required, the Engineer reserves the right to have them washed by the Contractor at no additional expense. Coarse and fine aggregates shall be delivered and stored separately at site. Aggregates shall not be stored on muddy ground or where they are likely to become dirty or contaminated.
- 4.1.3 Fine aggregate shall be hard coarse sand, crushed stone or gravel screenings and shall conform to requirements of PS 243 and/or BS 882 and/or ASTM C 33. Only fine aggregate of grading zones 1 to 3 (BS 882) shall be used.
- 4.1.4 Coarse aggregate shall be gravel or crush stone of hard, durable material free from laminated structure and conforming to PS 243 and/or BS 882 and/or ASTM C 33 graded as follows for use in mass concrete as in foundations:

<u>Total Passing B.S. Sieve</u>	<u>Percent by weight</u>
3 in. (76.20 mm) :	100
1.5 in. (38.10 mm) :	95-100
0.75 in. (19.05 mm) :	30-70
0.38 in. (9.52 mm) :	10-35
0.19 in. (4.76 mm) :	0-5

Coarse aggregate for all cast-in-place concrete other than mass concrete as for foundations shall be graded with the following limits:

Total Passing B.S. Sieve			Percent by weight
.5 in.	(38.10 mm)	:	100
0.75 in.	(19.05 mm)	:	95-100
0.38 in.	(9.52 mm)	:	25-55
0.19 in	(4.76 mm)	:	0-10

4.1.5 Wherever feasible, the nominal maximum size of aggregate for cast- in- place reinforced concrete slabs and other members, shall be 3/4 inch. If there are difficulties in placing such a concrete the maximum size may be restricted to 1/2 inch provided the requirements for strength are satisfied. The grading requirements of 1/2 inch or 3/8 inch down aggregate shall be agreed to with the Engineer as per relevant ASTM/BS standards.

4.1.6 The nominal maximum size of the aggregate for Precast concrete shall not be larger than one fifth of the narrowest dimension between sides of forms, or one-third of the depth of slabs or three-fourths of the minimum clear distance between reinforcing bars or between bars and forms, whichever is least. In Precast columns the nominal maximum size of the aggregate shall be limited as above but shall not be larger than two-thirds of the minimum clear distance between bars.

4.1.7 Coarse aggregates in Precast concrete of normal weight may be of one maximum size for all concrete placed in 1 day when quantities to be placed are too small to permit economical use of more than one mix design.

When a single mix design is so used, the maximum nominal size shall be as required for the most critical condition of concreting, in accordance with the requirements of clause (4.1.6) above.

4.1.8 Except where it can be shown to the satisfaction of the Engineer that a supply of properly graded aggregate of uniform quality can be maintained over the period of the work, the grading of the aggregates shall be controlled by obtaining the 3/4" maximum nominal size, the different sizes being stocked in separate stock piles and recombined in the correct proportion for each batch at the batching plant. The materials shall be stock-piled for a period before use so as to drain nearly to constant moisture content (as long as site and other conditions permit, preferably for at least a day). The grading of the coarse and fine aggregates shall be tested at least once for every 100 tons supplied, to ensure that the grading is uniform and same as that of the samples used in the preliminary tests.

4.1.9 For use in fire proof concrete, the aggregates shall be fire clay and semi-acidic fine ground. The use of broken fire clay bricks as coarse aggregate and waste of semi-acidic refractory particles as fine aggregate can be allowed.

4.2 Cement

4.2.1 The cement shall be fresh and of approved origin and manufacture. It shall be one of the following as may be specified by the Engineer.

- Ordinary or Rapid Hardening Portland cements complying with the requirements of PS 232 or BS 12 or ASTM C 150.
- Sulphate Resisting Portland/Cement complying with the requirements of PS 612 or BS 4027 or ASTM C 150.

4.2.2 Unless otherwise specified, ordinary Portland cement complying with the requirements of BS 12 shall be used.

- 4.2.3 For all fair faced concrete it will be necessary to use approved cement with a view to obtain a light shade concrete as approved by the Engineer.
- 4.2.4 The Contractor shall supply to the Engineer at fortnightly intervals, test certificates with the appropriate standard in respect of the samples of cement from the work-site. These tests shall be carried out in a laboratory approved by the Engineer.
- 4.2.5 Only one brand of each type of cement shall be used for concrete in any individual member of the structure. Cement shall be used in the sequence of receipt of shipment, unless otherwise directed.
- 4.2.6 There shall be sufficient cement at site to ensure that each section of work is completed without interruption.
- 4.2.7 Cement reclaimed from cleaning of bags or from leaky containers shall not be used.
- 4.2.8 The Contractor shall provide and erect (at his cost) a suitable plain, dry, well ventilated, weather-proof and water proof shed of sufficient capacity to store the cement.
- 4.2.9 Cement shall be used as soon as possible after delivery and cement which the Engineer considers has become stale or unsuitable through absorption of moisture from the atmosphere or otherwise shall be rejected and removed immediately from the site at the Contractor's expense. Any cement in containers damaged so as to allow the contents to spill or permitting access of the atmosphere prior to opening of the container at the time of concrete mixing shall be rejected and removed immediately from the site at the Contractor's expense.
- 4.2.10 The mixing together of different types of cement will not be permitted.

4.3 Water

Only clean water from the city supply, tube well installed at the site or from other sources approved by the Engineer shall be used. The Contractor shall supply sufficient water for all purposes, including mixing the concrete, curing and cleaning plant and tools. Where doubt exists as to the suitability of the water, it shall be tested in accordance with BS 3148. Where water can be shown to contain any sugar or an excess of acid, alkali or salt, the Engineer may refuse to permit its use.

In case of doubt, the Engineer may require that concrete mixed with water proposed to be used should not have a compressive strength lower than 90 percent of the strength of concrete mixed with distilled water.

4.4 Additive

All additives such as foaming and water proofing agents shall be from a manufacturer approved by the Engineer.

Air Entraining Admixtures shall conform to ASTM C 260. Other Admixtures shall conform to ASTM C 494.

5. **NOMINAL CONCRETE MIXES**

5.1 Proportions of Mix

5.1.1 Cement and aggregates:

Cement, fine aggregate and the coarse aggregate shall be weighed separately. The proportions of cement to fine aggregate and coarse aggregate shall be

adjusted so as to provide the concrete of the required crushing strength when tested as set out in Table 1.

5.1.2 The Contractor shall regulate and arrange mixing of the ingredients for the designed mix of the concrete by weight-batching. The cost of designing the mix shall be borne by the Contractor.

5.1.3 Water/Cement ratio:

The quantity of water used shall be just sufficient to produce a dense concrete of adequate strength and workability for its purpose. For all external work and foundations the water/cement ratio should not exceed 0.55 for concrete Class A, B and C.

5.1.4 Workability:

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

'Workability' shall be determined by either the slump or compaction factor tests as directed by the Engineer and these shall be performed in accordance with the methods given in PS 422 to PS 177 or ASTM C 143.

The slump or compaction factor for each class of concrete shall be determined during the preliminary Test mixes and the value obtained shall not be modified without the written consent of the Engineer. Unless otherwise permitted or specified, the concrete shall be proportioned and produced to have a slump of 3 inch or less for consolidation by vibration. A tolerance of upto 1 inch above the indicated maximum shall be allowed for individual batches provided the average for all batches or the most recent 10 batches tested, which ever is fewer, does not exceed the maximum limit. Concrete of lower than usual slump may be used provided it is properly placed and consolidated.

5.2 Strength requirements for concrete

5.2.1 Portland cement concrete when aggregates comply with BS 882.

5.2.2 Concrete made with Portland cement shall comply with the strength requirements of Table 1, columns 4&6 (Works Test).

Table 1: Strength requirements for Portland concrete with aggregates complying with BS. 882.

Class of Concrete (kg)	Nominal Design Mix	Min Cement per Cu.ft of compacted concrete (lb.)	Cube strength at 28 days after mixing & pouring (psi)		Alternative Cube strength at 7 days after mixing & pouring (psi)		Maximum water consumption per 110 lb. bag of cement (gallon)
			Preliminary tests	Works tests	Preliminary tests	Works tests	
1	2	3	4	5	6	7	8
A	1:1:2	30.00	5800	4350	3875	2900	4.40
B	1:1-1/2:3	22.00	4900	3750	3300	2450	5.06
C	1:2:4	18.00	4000	3000	2700	2000	5.28
D	1:3:6	13.00	2000	1550	1350	1000	7.05
E	1:4:8	9.50	-----	1000	-----		7.27

**Note: Conversion Factors. 1 psi = 0.006897 MPa 1 gal = 4.54 liter
1 lb. = 0.4537 Kg.
1cu.ft. = 0.028 cum.**

- 5.2.3 The strengths given in Table 1 are based on the assumption that average temperature is 20 degree C. Where accurate records of temperature are kept, allowance may be made for change of temperature or the cubes may be tested at the equivalent maturity.
- 5.2.4 All structural concrete shall conform to BS 5328.
- 5.2.5 Unless otherwise stated, the types of concrete shall be classified on the basis of compressive strength requirements. The Contractor shall provide Mix design by weight for each class of concrete.

Manufacture 12 test cubes for each 3 mix design batches (6 x 6 x 6) inches in accordance with the Mix design batching by weight and test 3 cubes each at 3,7,14 & 28 days intervals in the presence of Engineer's Representative and submit all relevant data and results of tests for approval of the Engineer. The Contractor shall obtain approval from the Engineer in writing for each Mix design before producing the actual concrete for the Works.

No payments for producing the Mix design, manufacture of test cubes and testing shall be paid. The Contractor shall include this cost in the relevant item of concrete.

5.3 **Batching**

- 5.3.1 All cement, including cement supplied in bulk, shall be batched by weight. A bag of cement may be taken as weighing 110 lb. with the prior approval of the Engineer.
- 5.3.2 Aggregates shall be batched by weight, due allowance being made for water content. Aggregates may be batched by volume through conversion of weigh batching, only with the prior permission of the Engineer. The apparatus for weight-batching may be an integral part of the mixer or a separate unit of a type approved by the Engineer. It shall be accurate within 2% and shall be checked for accuracy at least once a week.
- 5.3.3 The quantity of additives i.e. foaming and water proofing agents etc. shall be as prescribed by the manufacturer or as directed by the Engineer.
- 5.3.4 Where the batching plant is of the type in which cement and aggregates are weighed in the same compartment, the cement shall be introduced into the compartment between two sizes of aggregates.
- 5.3.5 Each batch shall be so charged into the mixer that some water will enter in advance of the cement and aggregates. Water shall continue to flow for a period which may extend to the end of the first 25 percent of the specified mixing time. Controls shall be provided to prevent batched ingredients from entering the mixer before the previous batch has been completely discharged.

5.4 **Mixing**

- 5.4.1 The concrete shall be mixed in an approved batch mixer conforming to the requirements of BS 1305. It shall be fitted with the manufacturer's plate stating the rates, capacity and the recommended number of revolutions per minute and shall be operated in accordance therewith. It shall be equipped with a suitable charging mechanism and an accurate water measuring device. The mixer shall be capable of thoroughly combining the aggregates, cement and water into a uniform mass within the specified mixing time and of discharging the concrete without harmful segregation.

- 5.4.2 Mixing shall continue for the period recommended by the mixer manufacturer or until there is apparently a uniform distribution of the materials and the mass is uniform in colour, whichever period is longer. If it is desired to use a mixing period of less than 1-1/2 minutes, the Engineer's approval shall be obtained in writing.
- 5.4.3 Controls shall be provided to ensure that the batch cannot be discharged until the required mixing time has elapsed. At least three quarters of the required mixing time shall take place after the last of the mixing water has been added.
- 5.4.4 The interior of the mixer shall be free of accumulations that will interfere with mixing action. Mixing blades shall be replaced when they have lost 10 percent of their original height.
- 5.4.5 Concrete shall be mixed only in quantities for immediate use. Concrete which has set shall not be retempered, but shall be discarded.

5.5 **Transporting**

- 5.5.1 The concrete shall be transported from the place of mixing to the place of final deposit as rapidly as practicable by means which will prevent segregation or loss of ingredients. All skip vehicles, or containers used for transporting the concrete shall be thoroughly cleaned.
- 5.5.2 During hot or cold weather, concrete shall be transported in deep containers, on account of their lower ratios of surface area to mass, which reduces the rate of loss of water by evaporation during hot weather and loss of heat during cold weather.

5.6 **Placing**

- 5.6.1 Before placing of concrete, formwork shall have been completed; water shall have been removed; reinforcement shall have been secured in place; expansion joint material, anchors and other embedded items shall have been kept in position; and the entire preparation shall have been approved by the Engineer.

No concrete is to be placed into the foundation trenches until the ground to receive the same has been examined and approved by the Engineer for this purpose.

- 5.6.2 Concrete shall be deposited continuously, or in layers of such thickness that no concrete will be deposited on concrete which has hardened sufficiently to cause the formation of seams or planes of weakness within the section. If a section cannot be placed continuously, construction joints shall be located as shown in the Contract Documents or as approved by the Engineer. Placing shall be carried out at such a rate that the concrete which is being integrated with fresh concrete is still plastic. Concrete which has partially hardened shall not be deposited. Temporary spreaders in forms shall be removed when the concrete placing has reached an elevation rendering their services unnecessary. They may remain embedded in the concrete only if made of metal or concrete and if prior approval has been obtained.
- 5.6.3 The actual sequence of construction proposed by the Contractor shall be subject to the Engineer's approval before construction starts on any part of the structure, and this sequence shall not be varied without the Engineer's approval.
- 5.6.4 The concrete after it has been mixed shall be placed as soon as it is practicable. Once the concrete has left the mixer, no more water shall be added, although the concrete may be mixed or agitated to help maintain

workability. The concrete shall not be used if, through any cause, the workability of the mix at the time of placing is too low for it to be compacted fully and to an acceptable finish by whatever means available.

The time between mixing and placing should be reduced, if the mix is richer or the initial workability of the mix is lower than normal, or if a rapid hardening cement or an accelerator is used, or if the work is carried out at a high temperature or exposed to a drying atmosphere.

The Contractor shall ensure that the delay between mixing and placing including consolidation does not exceed 45 minutes under any circumstances. Any concrete which does not satisfy this requirement shall be rejected.

- 5.6.5 Concrete shall be deposited as nearly as possible in its final position to avoid segregation due to re-handling or flowing. In no circumstances may concrete be railed or made to flow along the forms by the use of vibrators.

Concreting shall be carried on as a continuous operation using methods which shall prevent segregation or loss of ingredients.

- 5.6.6 The free fall of concrete shall not be allowed to exceed 6 feet. Where it is necessary for the concrete to be lowered more than this depth, it is not to be dropped into its final position, but shall be placed through pipes fed by a hopper. When a pipe is used for placing concrete the lower end shall be kept inside or close to the freshly deposited concrete. The size of the pipe shall be not less than 9 inch in diameter.

- 5.6.7 'Mass-concrete' shall be placed in layers approximately 18 inch thick. Vibrator heads shall extend into the previously placed layer.

- 5.6.8 The workmen carrying concrete to the site, and all other workmen moving about on the reinforcement before the concrete is placed, shall move only along runways or planks placed for the purpose and no person shall be allowed to walk on the reinforcement itself.

- 5.6.9 Prior to the laying of concrete on load bearing masonry walls, bearing plates and at other points, as may be directed by the Engineer, the surface will be brought to a true, hard and smooth level surface using cement sand mortar in the ratio of 1 volume of cement to 3 volumes of sand. Two layers of building paper weighing .082 lb./ft² will then be laid flat to separate the concrete from the surface on which it is to be laid.

5.7 **Construction Joints**

- 5.7.1 Concreting shall be carried out continuously up to construction joints, the position and arrangement of which shall be predetermined by the Engineer.

- 5.7.2 Joints not shown on the drawings shall be so made and located as to least impair the strength of the structure and shall need prior approval of the Engineer. In general, they shall be located near the middle of the spans of slabs and beams unless a secondary beam intersects a main beam at this point, in which case the joint in the main beam shall be offset a distance equal to twice the width of the secondary beam. Joints in walls and columns shall be at the underside of floors, slabs or beams and at the top of footings or floor slabs. Beams, brackets, columns capitals, haunches and drop panels shall be placed at the same time as slabs. Joints shall be perpendicular to the main reinforcement.

- 5.7.3 All reinforcing steel shall be continued across joints. Keys and inclined dowels shall be provided as directed by the Engineer. Longitudinal keys at least 1-1/2 inches deep shall be provided in all joints in walls and between walls and slabs or footings.

- 5.7.4 When the work has to be resumed on a surface which has hardened, such surface shall be roughened in an approved manner which will expose the aggregate uniformly and will not leave laitance, loosened particles of aggregate or damaged concrete at the surface.
- 5.7.5 The hardened concrete of construction joints and of joints between footings and walls or columns, between walls or columns and beams or floors they support, joints in un-exposed walls and all others not mentioned herein shall be dampened (but not saturated) immediately prior to placing of fresh concrete.
- 5.7.6 The hardened concrete of joints in exposed work, joints in the middle of beams, and slabs; and joints in work designed to contain liquids shall be dampened (but not saturated) and then thoroughly covered with a coat of cement grout similar in proportions to the mortar in the concrete. The grout shall be as thick as possible on vertical surfaces and at least 1/2 inch thick on horizontal surfaces. The fresh concrete shall be placed before the grout has attained initial set.
- 5.7.7 Where the concrete has not fully hardened, all laitance shall be removed by scrubbing the wet surface with wire or bristle, and brushed, care being taken to avoid dislodgment of particles of aggregate. The surface shall then be coated with neat cement grout. The first layer of concrete to be placed on this surface shall not exceed 6 inch in thickness, and shall be well rammed against old work, particular attention being paid to corners and closed spots.
- 5.7.8 Stop ends for movement joints or construction joints shall be made by splitting them along the lines of reinforcement passing through them, so that each portion can be positioned and removed separately without disturbance or shock to the reinforcement or the concrete. Stop ends made of expanded metal or similar material may only be left permanently in the concrete with prior written approval of the Engineer. Where such stop ends are used, no metal may be left permanently in the concrete closer to the surface of the concrete than the specified cover to the reinforcement.

5.8 **Expansion Joints**

Expansion joints shall be provided wherever indicated on the Drawings or as directed by the Engineer. In no case shall the reinforcement, corner protection angles, or other embedded items be permitted to extend continuously through any expansion joint.

All expansion joints shall be carefully placed so as not to be displaced during concreting. The method of placing the expansion joints shall be strictly in accordance with the Drawings and/or as directed by the Engineer. All materials for use in the expansion joints shall have prior approval of the Engineer before placing order for supply.

5.9 **Embedded Items**

- 5.9.1 The material, design and location of water-stops in joints shall be as indicated in the Contract Documents. Each piece of pre-molded water stop shall be of maximum practicable length in order that the number of end joints will be held to a minimum.

Joints at intersections and at ends of pieces shall be made in the manner most appropriate to the material being used. Joints shall develop effective water-tightness fully equal to that of the continuous water-stop material, shall permanently develop not less than 50 percent of the mechanical strength of the parent section and shall permanently retain their flexibility.

- 5.9.2 Electric conduits and other pipes which are planned to be embedded shall not, with their fittings, displace more than four percent of the area of the cross

section of a column on which stress is calculated or which is required for fire protection. Sleeves, conduits, or other pipes passing through floors, walls, or beams shall be of such size or in such location as not to impair unduly the strength of the construction; such sleeves, conduits, or pipes may be considered as replacing structurally in compression the displaced concrete, provided that they are not exposed to rusting or other deterioration, are of uncoated or galvanized iron or steel not thinner than standard steel pipe, have a nominal inside diameter not over 2 inch and are spaced not less than three diameters on centers. Except when plans of conduits and pipes are approved by the Engineer, embedded pipes and conduits other than those merely passing through, shall not be larger in outside diameter than one third the thickness of the slab, wall, or beams in which they are embedded nor so located as to impair unduly the strength of the construction. Sleeve pipes, or conduits of any material not harmful to concrete and within the limitations of this section may be embedded in concrete with the approval of the Engineer provided they are not considered to replace the displaced concrete.

- 5.9.3 All sleeves, inserts, anchors, and embedded items required for adjoining work or for its support shall be placed prior to concreting.

All Contractors whose work is related to the concrete or must be supported by it shall be given ample notice and opportunity to introduce and/or furnish embedded items before the concrete is placed.

- 5.9.4 Expansion joint material, water-stops and other embedded items shall be positioned accurately and supported against displacement. Voids in sleeves, inserts and anchor slots shall be filled temporarily with readily removable material to prevent the entry of concrete into the voids.

5.10 **Pre-Cast Concrete**

Pre-cast concrete units shall be fair faced (OR WITH ARCHITECTURAL FINISH or with an approved pattern finish) cast to the sizes and dimensions as indicated on the Drawings. The concrete used for pre-cast units shall conform to the specifications laid down for cast in situ reinforced cement concrete unless otherwise required and directed by the Engineer.

The Contractor shall be required to submit a sample of pre-cast unit for the approval of the Engineer; all pre-cast units shall strictly conform to the approved sample.

Pre-casting platform of the size and at the location approved by the Engineer shall be constructed. The concrete in one pre-cast unit shall be placed in one operation, in accordance with the details shown on the Drawings.

The material and design of formwork and the method of pre-casting the units shall be approved by the Engineer.

The erection/installation and removal of the pre-cast units from the pre-casting platform shall not be permitted until and unless they are properly cured to the satisfaction of the Engineer.

All pre-cast units shall be smoothly finished to the required lines, grades, angles, etc. Holes, grooves, pockets and hooks shall be provided as shown and/or as directed by the Engineer. The units shall be properly stacked on a platform without causing any cracks and damages. Curing of all the pre-cast units shall be done in accordance with the relevant BS code/approval of the Engineer.

5.10.1 Erecting Pre-cast Units

All the pre-cast units shall be transported and erected into position in a manner as approved by the Engineer.

The Contractor shall submit his proposal in this regard and obtain approval from the Engineer in advance.

5.10.2 Lifting Beams

The Contractor shall use lifting beams at his own cost for erecting pre-cast members where the Engineer so directs. Lifting beams shall be supplied and erected by the Contractor, at his own cost, at all points where lifting is necessary for maintaining the plant but is inaccessible to mobile cranes or, alternatively, covered by overhead traveling cranes. The Contractor, however, is to supply the trolleys and erect them on the lifting beams, and to test operation of installed equipment.

5.11 **Cement Concrete Pavements**

For all concrete work relevant specifications of this section shall apply.

5.11.1 Side Forms and Construction

Side forms shall be of steel or any other suitable material and of a design as approved by the Engineer.

In general, only materials and methods that have proved their acceptability by past performance will be considered. All form shall be constructed so that they can be removed without hammering or prying against the concrete.

Horizontal joints in the forms will not be permitted. Forms shall be thoroughly cleaned and oiled with linseed/mineral oil shall be given two coats of niter-cellulose lacquer each time they are used.

The forms shall be set on a thoroughly compacted base true to line and level and firmly secured in position by appropriate methods. Conformity with the alignment and levels shown on the Drawings shall be checked as and when required by the Engineer. Where necessary corrections shall be made immediately before placing the concrete; where any form has been disturbed it shall be reset and rechecked.

Pavements shall be constructed in panels of sizes as shown on the Drawings. The panels shall be laid alternately, the adjoining panels being concreted when the side forms are struck and the jointing materials placed, inspected and approved by the Engineer. Each panel is to be concreted in one operation and no interruptions shall be permitted during the operation. The concrete shall be tipped from the trolley slightly in advance of the working place and then shoveled into position. The spreading shall be carried out very carefully. Compaction shall be done by means of vibro-compactors of approved surface vibrators. If a vibro-compactor is used, it shall be operated on the concrete and will not be allowed to strike or displace the forms. The spreading and compacting of the successive layers shall proceed without interruptions and as quickly as practicable so as to ensure that the slab is monolithic throughout its depth.

The wearing surface shall be laid while the base concrete is still wet and screeded to line and level. When the initial set takes place the surface shall be troweled smooth with a steel trowel to provide a dense closed surface.

All the joints shall be carefully formed as shown on the Drawings or as directed by the Engineer. The joint filler together with performed groove shall provide complete separation of adjacent slabs. The joints shall all be sealed with bitumen as shown on the Drawings and as directed by the Engineer.

5.11.2 Protection and Curing

- General Requirements:

Concrete shall be protected adequately from injurious action by sun, rain, flowing water and mechanical injury, and shall not be allowed to dry from the time it is placed until the expiry of the minimum curing periods specified hereinafter. Water curing shall be accomplished by keeping the surface of the concrete continuously wet by covering with water or with an approved water saturated covering. Where wood forms are left in place for curing, they shall be kept sufficiently damp at all times to prevent openings at the joints and drying out of the concrete. All portions of the structure shall be kept moist for the full curing periods, specified hereinafter.

When liquid membrane curing compound is used the surface of the concrete shall be protected from traffic or other abrasive action that may break the membrane, for the full period of curing. The membrane curing compound shall be colourless or light coloured and shall be approved by the Engineer and shall comply with ASTM Designation C 309.

- Curing Periods

The curing period shall be at least 10 days, or as directed by the Engineer.

- Removal of Forms

The Contractor shall exercise great care in avoiding damage to joints, arises, dowel bars etc., while removing the forms. Under no circumstances will the use of pry bars between the forms and pavement be permitted. Side forms shall not be removed until at least 40 hours have elapsed from the time of completing the concreting of the slab which they contain. In no case shall forms be removed until the concrete has hardened sufficiently to permit removal without damage to the concrete. Concrete work shall be protected from injury resulting from the storage or movement of material during construction.

5.11.3 Finishing

All unformed surfaces shall be finished with a wood float except as otherwise specified. Visible vertical surfaces shall have all projections and irregularities removed. The entire surface shall be rubbed if required by the Engineer, with a No. 16 carborundum brick, or other abrasive until even, smooth and of uniform appearance, and shall be shed clean. Plastering of surface, application of cement or other coating will not be permitted.

All exposed corners shall be chamfered, 1"x 1" (2.5 cms x 2.5 cms) unless otherwise mentioned or shown on the plans or directed by the Engineer. Concrete surfaces which will be covered with other materials shall be screeded without floating.

5.11.4 Spreading, finishing and floating of concrete in pavements

- General Requirements

The striking off, compacting and floating of concrete shall be done by mechanical methods, if approved by the Engineer. Where the Engineer determines that it is impracticable to use mechanical methods, manual methods of spreading, finishing and floating may be used on pavement lines as indicated on the Drawings.

- Mechanical Methods

The concrete shall be spread uniformly between the forms, immediately after it is placed, by means of an approved spreading machine. The spreader shall be followed by an approved finishing machine equipped with two oscillating or reciprocating screeds. The spreading machine or the finishing machine shall be equipped with vibrating equipment that will vibrate the concrete for the full paving width. Internal vibrators shall be used adjacent to the longitudinal edge of the pavement. These vibrators shall be attached to the rear of the spreading machine or to the finishing machine. Vibrators shall not rest on view pavements or side forms or in contact with any dowel bars and the arrangement of power supply to the vibrators shall be such that when the motion of machine is stopped, vibration shall cease. The rate of vibration shall be not less than 8000 vibrations per minute. The concrete shall be spread to full width before being struck off and compacted so that the surface will conform to the finished grade and cross-section as shown on the plans and at the same time leave sufficient material for the floating operation. The spreading & finishing machine shall move over the pavement as many times and at such intervals as may be required by the Engineer to ensure thorough compaction.

Except as otherwise specified, after the pavement has been struck off and compacted, it shall be finished with an approved longitudinal float. The Contractor may use a longitudinal float composed of one or more cutting and smoothing floats, suspended from and guided by rigid frame. The frame shall be carried by four or more visible wheels riding on and constantly in contact with the forms.

The contractor may use a longitudinal float which works with a sawing motion, while held in a floating position parallel to the road centre line and passing gradually from one side of the pavement to the other. Movements ahead, along the centre line of the road, shall be in successive advances of not more than half the length of the float.

Instead of using other type of longitudinal float a single machine which will affect satisfactory compaction, finishing and floating may be used. This machine may be towed by a spreading machine. This combination, finishing floating machine shall be equipped with screeds and vibrators as hereinafter specified for spreading and finishing machine. Floating shall be accomplished by means of a non-oscillating float held in a suspended position from the frame.

If any spreading, finishing and floating equipment is not maintained in full working order or if the equipment as used by the Contractor proves inadequate to obtain the results prescribed, such equipment shall be improved or satisfactory equipment substituted or added at the direction of the Engineer.

- Manual Methods

When striking-off and compacting by manual methods is permitted, the concrete shall be leveled and then struck-off to such an elevation that, when properly compacted, the surface will conform to the required grade and cross-section. The strike board shall be moved forward with a combined longitudinal and transverse motion, the manipulation being

such that neither end is raised from the side forms during the process. While striking off, a slight excess of concrete shall be kept in front of the cutting edge at all times. Prior to tamping, the concrete along the forms shall be thoroughly spaded or vibrated. The entire area of pavement shall be tamped or vibrated a manner that will ensure maximum compaction. The concrete shall be brought to the required grade and shape by the use of a tamper consisting of a heavy plank whose length exceeds the width of the pavement by 1 foot or by the use of a mechanical vibrating unit spanning the full width of the spread. The tamper shall be constructed with properly trussed roads to stiffen it and prevent sag and shall be shod with a heavy strip or metal for a tamping surface. The tamper shall be moved with a combined tamping and longitudinal motion, raising it from side form and dropping it so that the concrete will be thoroughly compacted and rammed into place. A small surplus material is compacted and rammed into front of the tamper or vibrating unit and tamping or vibrating shall continue until the true cross-section is obtained and the mortar flushes slightly to the surface.

On grades in excess of 5 percent where hand methods are permitted, a little strike board shall follow at a speed of 25 ft to 50 ft per hour back of the heavy strike board, and shall be used in the same way, so as to remove waves caused by flow of concrete.

Where hand tamping is permitted, not less than two strike boards or tampers shall be used for production in excess of 350 Cu.ft. After the concrete has been compacted, it shall be smoothed with a wooden float where necessary, as directed by the Engineer.

- Longitudinal Floating

Manual floats shall be at least 12 ft. in length not less than 6 inches in width and shall be properly stiffened to prevent bending or warping. In using the float, it shall be held parallel to centre line of the pavement at all time and shall be moved laterally across the pavement from one side or edge to the other until all high areas are cut down and floated into depressions, leaving a surface that is smooth and true to grade. Batch transverse passage of the longitudinal manual float shall lap the proceeding passage by half.

- First Straight Edge Testing

Immediately following final floating the entire area of the pavement shall be tested with a 10 ft. (approx. 3. meters) straight edge. Any depressions found shall be immediately filled with fresh concrete which shall be struck off compacted and finished. High areas shall be worked down and refinished. The straight edge testing and refloating shall continue until the pavement has the required surface contour.

- Burlap (Coarse Canvas) Dragging

After the first straight edge testing and when most of the water sheet has disappeared from the surface and just before the concrete becomes non-plastic, the surface shall be dragged with a strip of burlap (coarse canvas) 3 ft. to 10 ft. wide and having a length 4 ft. more than the width of the slab. The burlap shall be dragged along the surface of the pavement in a longitudinal direction. Burlap shall be clean and kept free from coatings of hardened concrete. It shall be moist at the time of use.

- Second Straight Edge Testing

After the concrete has hardened sufficiently to permit walking on it, the surface of the pavement shall again be tested with a 10 ft. straight

edge. Any portion of the pavement which shows a variation from the testing edge of more than 1/8 inch shall be corrected by cutting, or shall be removed and replaced at the expense of the Contractor.

5.11.5 Expansion and Contraction Joints

- i. All the expansion and contraction joints shall be carefully formed as shown on the Drawings or as directed by the Engineer. As regards dowel bars and joint assemblies, such stakes, brackets or other devices shall be used, as necessary to keep the entire joint assembly in true vertical and horizontal position. The joint filler together with the preformed groove shall provide complete separation of adjacent slabs. The joints shall all be sealed with the specified non-extruding sealing compound set in a 3/4 inch wide preformed chase as shown on the Drawings. The preformed chase shall be thoroughly cleaned of all dust, debris, stones or other hard material prior to its sealing. The riser of all joints shall be rounded to a radius as shown on the Drawings before the concrete hardens.
- ii. The joints sealing compound shall be hot poured bitumen or approved sealing compound for concrete pavements complying with BS-2499 for hot tropical climates and heavy duty industrial site subject to severe exposure. All joints are to be filled with flexcell expansion joint filler, or an approved elastic, compressible, durable and rot-proof equivalent of sufficient rigidity to enable it to be satisfactorily installed in the joint and resist deformation during the passage of the concreting equipment. The filler is to be of the same thickness as the joint width. Holes to accommodate the dowel bars shall accurately be drilled or punched out. Where shown on the Drawings, dowel bars of required diameter shall be placed at the specified spacing. The bars shall be lubricated with an approved lubricant. One end of the dowel bar at expansion joints shall be provided with a closely fitting sleeve 3 inch long, consisting of bitumen coated plastic or other approved material to permit expansion. A loose plug 1 inch deep of approved compressible filling material shall be inserted into the sleeve as shown on the Drawings at the end of the bar. All the dowel bars shall be mild steel bars of the size shown on the Drawings and shall conform to the requirements as specified in the section 'Concrete'.
- iii. Contraction joints shall be provided as shown on the Drawings.

The assembly and method of constructing the expansion joints/contraction joints shall be subject to the approval of the Engineer.

5.12 Consolidation

- 5.12.1 All concrete shall be consolidated by vibration, spading, rodding or forking so that the concrete is thoroughly worked around the reinforcement, around embedded items and into corners of forms, eliminating all air or stone pockets which may cause honeycombing, pitting, or planes of weakness. Internal vibrators shall have a minimum frequency of 8000 vibrations per minute and sufficient amplitude to consolidate the concrete effectively. They shall be operated by competent workmen. Use of vibrators to transport within forms shall not be allowed. Vibrators shall be inserted and withdrawn at points approximately 18 inch apart. At each insertion, the duration shall be sufficient to consolidate the concrete but not excessive so as to cause segregation, generally from 5 to 15 sec. A spare Vibrator shall be kept on the job site during all concrete placing operations.

Where the concrete is to have an as-cast finish, a full surface of mortar shall be brought against the form by the vibration process, supplemented, if necessary, by spading to work the coarse aggregate back from the formed surface.

- 5.12.2 If there is any tendency for the mix to segregate during consolidation, particularly if this produces excessive laitance, the mix proportions shall be modified to effect an improvement in the quality of the concrete to the satisfaction of the Engineer and in conformity with the provisions of Clause 5.
- 5.12.3 Vibrator shall not be allowed to contact the form work for exposed concrete surfaces.
- 5.12.4 Mechanical vibrators shall be of a type suited in the opinion of the Engineer to the particular conditions.
- 5.12.5 Over-vibration or vibration of very wet mixes is harmful and should be avoided.

5.13 **Curing and Protection**

- 5.13.1 Beginning immediately after placement, concrete shall be protected from premature drying, excessively hot or cold temperatures and mechanical injury and shall be maintained with minimum moisture loss at a relative constant temperature for the period necessary for hydration of the cement and hardening of the concrete. The materials and methods of curing shall be subject to approval of the Engineer.
- 5.13.2 For concrete surfaces not in contact with forms, one of the following procedures shall be applied immediately after completion of placement and finishing:
 - Ponding or continuous sprinkling.
 - Application of absorptive mats or fabric kept continuously wet.
 - Application of waterproof sheet materials approved by the Engineer.
 - Application of other moisture-retaining covering as approved.
 - Application of a curing compound conforming to ASTM C 309.

The compound shall be applied in accordance with the recommendations of the manufacturer immediately after any water sheen which may develop after finishing has disappeared from the concrete surface. It shall not be used on any surface against which additional concrete or other material is to be bonded unless it is proved that the curing compound will not prevent bond, or unless positive measures are taken to remove it completely from areas to receive bonded applications.

- 5.13.3 Moisture loss from surfaces placed against wooden forms or metal forms exposed to heating by the sun shall be minimized by keeping the forms wet until they can be safely removed. After form removal the concrete shall be cured until the end of the time prescribed for curing.
- 5.13.4 Curing in accordance with sub-clause 5.13.1 & 5.13.2 above shall be continued for at least 10 days in the case of all concrete except concrete with rapid-hardening Portland Cement for which the period shall be at least 3 days. Alternatively, if tests are made of cubes kept adjacent to the structure and cured by the same methods, moisture retention measures may be terminated when the average compressive strength has reached 70 percent of the minimum specified works cube strength. If one of the first four curing procedures of sub-clause 5.13.2 is used initially, it may be replaced by one of

the other procedures of that sub-clause any time after the concrete is one day old provided the concrete is not permitted to become surface dry during the transition.

- 5.13.5 When the mean daily outdoor temperature is less than 5 degree C (41 deg. F) temperature of the concrete shall be maintained between 10 and 20 degrees C (50 to 68 deg. F) for the required curing period of sub-clause 5.13.4.

When necessary, arrangements for heating, covering insulation or housing the concrete work shall be made in advance of placement and shall be adequate to maintain the required temperature without injury due to concentration of heat. Combustion heaters shall not be used during the first 24 hours unless precautions are taken to prevent exposure of the concrete to exhaust gasses which contain carbon dioxide.

- 5.13.6 During hot weather when necessary, provision for wind-brakes, shading for spraying, sprinkling, ponding or wet covering with a light coloured material shall be made in advance of placement. Such protective measures shall be taken as quickly as concrete hardening and finishing operation will allow.

- 5.13.7 Changes in temperature of the air immediately adjacent to the concrete during and immediately following the curing period shall be kept as uniform as possible and shall not exceed 3 deg. C (37 deg. F) in any one hour or 10 degree C (50 deg. F) in any 24 hour period.

- 5.13.8 During the curing period, the concrete shall be protected from damaging mechanical disturbances, such as load stresses, heavy shock and excessive vibrations. All finished concrete surfaces shall be protected from damage by construction equipment, materials or methods by application of curing procedures, and by rain or running water. Self-supporting structures shall not be loaded in such a way as to over stress the concrete.

5.14 **Works in Extreme Weather**

- 5.14.1 Unless adequate protection is provided and approval is obtained from the Engineer, concrete shall not be placed during rain.

Rain water shall not be allowed to increase the mixing water nor to damage the surface finish.

- 5.14.2 When the temperature of the surrounding air is expected to be below 5 deg. C during placing or within 24 hours thereafter, the temperature of the plastic concrete, as placed, shall be no lower than 13 deg. C for sections less than 12 inch in any dimension nor 10 deg. C for any other sections.

When necessary, concrete material should be heated before mixing and carefully protected after placing, in general, heating or mixing water alone to about 60 deg. C may be sufficient for this purpose. Dependence should not be placed on salt or other chemicals for the prevention of freezing. No frozen material or materials, containing ice shall be used. All concrete damaged by frost shall be removed. It is recommended that concrete exposed to the action of freezing weather should have entrained air and the water content of the mix should not exceed 5.5 gallon/bag of cement.

If water or aggregate is heated above 38 deg. C the water shall be combined with the aggregate in the mixer before cement is added. Cement shall not be mixed with water or with mixtures of water and aggregate having a temperature greater than 38 deg. C.

- 5.14.3 During hot weather, the temperature of the concrete as placed shall not be so high as to cause difficulty from loss of slump, flash set, or cold joints and should not exceed 32 deg. C. For massive concrete, this temp. should not exceed 21 degree C. When the temp. of the concrete exceeds 32 degree C,

precautionary measures approved by the Engineer shall be put into effect. When the temperature of the steel is greater than 50 deg. C, steel forms and reinforcement shall be sprayed with water just prior to placing the concrete. The ingredients shall be cooled before mixing, or flaked ice or well crushed ice of a size that will melt completely during mixing may be substituted for all part of the mixing water if, due to high temperature, low slump, flash set or cold joints are encountered.

Other precautions recommended by ACI Standard 305-72 shall also be adopted.

6. TEST OF CONCRETE QUALITY

- 6.1 The Contractor shall provide samples of concrete for testing at the Engineer's direction. Proper facilities shall be provided for making and curing the test specimens in accordance with PS 560 and PS 849. A competent person shall be employed by the Contractor whose first duty shall be to supervise all stages in the preparation and placing of the concrete. All test specimens shall be made and site tests carried out under his direct supervision.
- 6.2 Preliminary cube tests and works cube test shall be performed in accordance with PS 560 and PS 849 at the discretion of the Engineer. Works transverse tests shall be performed in accordance with sub-clauses 208 c and 610 d of CP 114. The standard of acceptance for preliminary and works tests shall be as given below.
- 6.3 The usual test for concrete with maximum size of aggregate upto 1-1/2 inch is the 6 inch cube tested in compression. Details of making and curing compression test cubes are given in PS 560, PS 849 and BS 1881 and details of the testing are given in Part 8 of BS 1881.
- 6.4 For all grades of concrete, preliminary cube strength test with the mixes and materials to be used shall be performed in accordance with PS 560, PS 849 and BS 1881 before the work is begun and subsequently whenever any change is to be made in the materials or in the proportions of materials to be used, or as required by the Engineer. The strengths shall comply with the standard of quality specified in accordance with Table 1 for preliminary tests. The cost of such testing shall be borne by the Contractor.
- 6.5 Test sample shall be taken at the mixer or as directed by the Engineer. The test specimens shall be cured in accordance with PS 560, PS 849 and BS 1881.

Records shall be kept of all test cubes identifying the mix used, the section of work for which the concrete was used and the date poured.
- 6.6 Five test cubes are to be tested for compressive strength as specified in BS 1881. These tests shall be carried out at site or in a laboratory approved by the Engineer. Two cubes shall be tested at the age of seven days and three at 28 days and the strengths determined are to comply with the standard of quality specified. The laboratory tests shall be carried out by an independent organization, such as Government Testing Laboratory or such other undertakings approved by the Engineer. The original test reports received from the above authorities should be submitted to the Engineer.
- 6.7 For all grades of concrete, the appropriate strength requirement shall be considered to be satisfied if none of the strengths of the cubes is below the specified cube strength or if the average strength of the three cubes is not less than the specified cube strength and the difference between the greatest and the least strength is not more than 20% of the average.
- 6.8 When the results of works cube tests show that the strength of any concrete is below the minimum specified, the Engineer may give instructions for the whole or part of the work concerned to be removed and replaced at the expense of the Contractor. The Contractor shall bear the cost of any other part of his, or any other contractor's work, which has to be removed and replaced as a result of the defective concrete. If any

concrete is held to have failed, the Engineer may order the proportions of that class of concrete to be changed in order to provide the specified strength.

7. FINISHING OF FORMED SURFACES

7.1 General

- 7.1.1 After removal of forms, the surfaces of concrete shall be given one or more of the finishes specified below in locations designated by the Contract Documents.
- 7.1.2 When finishing is required to match a small sample furnished to the Contractor, the sample finish shall be reproduced on an area at least 100 Sq. ft. in an inconspicuous location designated by the Engineer before proceeding with the finish in the specified location.
- 7.1.3 Allowable deviations from plumb or level and from the alignment, profile grades, and dimensions are specified in clause 9. Tolerances for concrete construction and defined as tolerances that are to be distinguished from irregularities in finish as described herein. The finish requirements for concrete surfaces shall be as generally specified in this clause and as indicated on the Drawings. Finishing of concrete surfaces shall be performed only by workmen who are skilled in concrete finishes. The Contractor shall keep the Engineer advised as to when finishing of concrete will be performed. Unless inspection is waived in each specific case, finishing of concrete shall be performed only in the presence of the Engineer. Concrete surfaces will be tested by the Engineer where necessary to determine whether surface irregularities are within the limits herein after specified. Surface irregularities are classified as abrupt or gradual.

Offsets caused by displaced or misplaced form sheeting or lining or sections, or otherwise defective form lumber will be considered as abrupt irregularities, and will be tested by direct measurements. All other irregularities will be considered as gradual irregularities, and will be tested by use of a template, consisting of a straight edge or the equivalent thereof for curved surfaces. The length of the template will be 6.5 ft. for testing of formed surfaces and 10 ft. for testing of unformed surfaces.

7.2 As-cast Finishes

Unless otherwise specified or indicated on the Drawings the classes of finish shall apply as follows:

7.2.1 Rough form finish:

No selected form facing materials shall be specified for rough form finish surfaces. Tie holes and defects shall be patched. Fins exceeding 1/4" in height shall be chipped off or rubbed off. Otherwise, surfaces shall be left with the texture imparted by the forms.

7.2.2 Fair face finish:

Fair face finish applies to concrete formed surfaces, the appearance of which is considered by the Engineer to be of special importance, such as surfaces of structures prominently exposed to public inspection. Surfaces of concrete structures requiring fair face finish is shown in the Drawings. Surface irregularities, measured as described in sub-clause 7.2.1, 'Rough form finish', shall not exceed 1/4 inch for gradual irregularities and 1/8 inch for abrupt irregularities, except that abrupt irregularities will not be permitted at construction joints. Abrupt irregularities at construction joints and elsewhere in excess of 1/8 inch and gradual irregularities in excess of 1/4 inch shall be reduced by grinding so as to conform to the specified limits. Abrupt

irregularities at construction joints shall be ground on level of 1 to 20 ratio of height to length.

Unless otherwise approved, repair of imperfections in formed concrete shall be completed within 24 hours after removal of forms. The form facing material shall produce a smooth, hard, uniform texture on the concrete. It may be plywood, tempered concrete-form-grade hardboard, metal, plastic paper or other approved material capable of producing the desired fair face finish. The arrangement of the facing material shall be orderly and symmetrical, with the number of seams kept to the practical minimum. It shall be supported by studs or other backing capable of preventing excessive deflection. Material with raised grain, torn surfaces, worn edge, patches, dents, or other defects which will impair the texture of the concrete surface shall not be used. Tie holes and defects shall be patched. All fins shall be completely removed.

7.2.3 Architectural Finish Concrete:

Architectural finish to concrete formed surfaces as shown on the Drawings is required by the Engineer where the architectural appearance of surfaces of structures exposed to public view is of special consideration and importance. The Contractor shall use approved special material for formwork and design the forms in conformity with the specified architectural patterns, textures and finishes in order to obtain first class architectural finish on formed concrete surface without any defect, irregularities, blemishes, imperfections and encrustation's.

Samples:

1. Submit to the Engineer a minimum of two units or portions of units of each Precast item required. Each pair of samples when accepted will describe the allowable limits between which variations can be acceptable.
2. Similar samples of in-situ concrete for approval by the Engineer, submit two samples, 2 Sq. ft. of each type of exposed in-situ concrete. All in-situ samples will remain at the construction site.

Sample approvals of Precast & in-situ concrete:

These samples will be reviewed and approved on the basis of colour, dimensional accuracy, finish of surfaces and general appearance. The same requirements for sample approval will be required for both Precast and in-situ concrete exposed surfaces.

Forms

The contractor must maintain the forms unusually tight and braces to prevent movement, mal-alignment and bleeding that will result in sand streaks, honeycomb, fins, stain or unsightly appearance.

If wood forms are chosen to be used by the Contractor they shall be constructed of 3/4 inch minimum thickness plywood constructed in a fashion to allow many re-uses with all surfaces sealed with a polyurethane varnish.

Edges, surfaces and corners of forms shall be sealed to prevent loss of any matrix or unequal absorption of water. Corners of wood forms shall be filled with suitable compound and all contact surfaces sealed with a polyurethane varnish.

Re-use of forms shall be subject to approval by the Engineer.

Curing:

Curing shall be done in shade (out of direct sunlight) and shall be for a minimum period of 4 days.

Finishing procedures:

"Finishing procedures for filling air void in smooth finished concrete developed by a formed surface":

While the concrete surface is still damp (not more than three days after removal of forms), apply a thin coat of medium consistency neat cement slurry by means of bristle brushes to provide a bonding coat within any pits or blemishes in the parent concrete; avoid coating large areas of the finished surface. Before slurry has dried or changed colour, apply a dry (almost crumbly) grout comprised of one part cement, of the type and brand of cement used in the original concrete, to one and one-half parts clean masonry sand with a fineness modulus of approximately 2.25 and complying with the gradation requirements of the ASTM Specifications C 144. Mix proper amounts of white cement and colouring with the parent mortar to produce a satisfactory colour match with the parent concrete after hardening. Use samples previously prepared.

Apply the finishing grout uniformly with damp (neither dripping wet nor dry) pads of coarse burlap approximately 6 inch square used as a float. Scrub the grout well into the pits to provide a dense mortar in all the imperfections to be filled. Allow the mortar to partially harden, from one to two hours, depending upon the weather. Avoid direct hot sunlight. If the air is hot and dry, keep the concrete surface damp during this period using a fine fog spray. When the grout has hardened sufficiently so it can be scraped from the surface with the edge of a steel trowel without damaging the grout from the small pits or holes, cut off all that can be removed with a trowel without delay; next allow the surface to dry thoroughly and rub it vigorously with clean, dry burlap to completely remove any dried grout. No visible film of grout shall remain after this rubbing. Complete the entire cleaning and grouting operation for the grout to dry after it has been cut with the trowel, so it can be wiped off clean with the burlap.

On the day after the repair work, the concrete surfaces should again be wiped off clean with dry burlap to remove any inadvertent dust; leave no built-up surfaces on the parent surfaces. Employ, if possible, a used piece of burlap containing old hardened mortar to act as a mild abrasive. Use of fine abrasive stone if needed to remove any remaining built-up film without breaking through the surface film of the original concrete. Such scrubbing should be light and sufficient only to remove excess material without working up a lather of mortar or changing the texture of concrete.

Following the final bagging or stoning operation, provide a thorough wash down with stiff bristle brushes to remove all extraneous materials and spray the concrete surface with a fine fog spray periodically to maintain a continually damp condition for at least three days after application of the pit repair grout.

Rust Stains:

All rust stains are to be removed employing the following procedure:

The rust stain shall be soaked for 10 minutes with a solution of 0.055 lb. of sodium citrate in 0.33 lb. water (brushing the solution at short intervals is satisfactory). Then the surface is sprinkled with crystals of sodium hydrosulfite and covered with a paste of Fuller's Earth and water. On a vertical surface, the

paste is applied with a trowel, with the crystals first sprinkled on the paste so they will be in direct contact with the stain. The paste is allowed to dry for 10 minutes then scraped off and the treatment repeated if necessary.

Repairing of Formed Surfaces:

It is the intention of Specification to require forms, mixture of concrete and workmanship so that concrete surfaces, when exposed, will require no patching. Any concrete which is not formed as required and conforming to approved samples or for any reason is out of alignment or level or shows a defective surface, shall be removed from the job by the Contractor at his expense unless the Engineer grants permission to repair the defective area. Permission to patch any such area shall not be considered a waiver of the Engineer's right to require a complete removal of defective work if the repair does not, in his opinion, satisfactorily restore the quality and appearance of the surface. The Engineer shall be the sole judge of acceptability of appearance.

7.3 **Finishes of Unformed Surfaces:**

7.3.1 **Monolithic Concrete Floor Finish'**

Where monolithic concrete floor finish is shown on the Drawings, placing shall proceed continuously for the full thickness of the course or RCC slab without change in concrete mix. Mixing water shall be the minimum required for proper placing, and will be as specified by the Engineer. After placing, floors, and other surfaces shall be floated with a wood float to a true surface and to elevation as shown on the Drawings. Where indicated on the Drawings, floor surfaces shall be steel trowel finished. Troweling shall be the minimum amount consistent with maintaining a smooth dense surface, and shall not be done until the mortar has hardened sufficiently, to prevent excess fine material from being worked to the surface, and shall produce a dense uniform surface, free from blemishes and trowel marks.

Gradual surface irregularities shall not exceed 1/16 inch. The addition of water, dry cement, or dry cement mortar, to the surface of the concrete to facilitate finishing will not be permitted.

7.3.2 **Equipment Foundations'**

Unless otherwise specified, exposed, surfaces of equipment foundations shall be given steel trowel finish to produce a surface similar to the specified concrete floor finish.

8. **REPAIR OF SURFACE DEFECTS**

8.1 **General**

8.1.1 Any concrete failing to meet the specified strength or not formed as shown on drawings, concrete out of alignment, concrete with surfaces beyond required tolerances or with defective surfaces which cannot be properly repaired or patched in the opinion of the Engineer shall be removed at Contractor's cost. The Engineer may reject any defective concrete and order it to be cut out in part or in whole and replaced at the Contractor's expense.

8.1.2 All ties and bolt holes and all repairable defective areas shall be patched immediately after form removal.

8.2 **Repair of Defective Areas**

- 8.2.1 All honeycombed and other defective concrete shall be removed down to sound concrete. The area to be patched and an area at least 6 inch wide surrounding it shall be dampened to prevent absorption of water from the patching mortar. A bonding grout shall be prepared using a mix of approximately 1 part cement to 1 part fine sand passing No.25 BS Sieve and shall then be well brushed into the surface.
- 8.2.2 The patching mixture shall be made of the same material and of approximately the same proportions as used for the concrete, except that the coarse aggregate shall be omitted and the mortar shall consist of not more than 1 part cement to 2-1/2 parts sand by damp loose volume. White Portland cement shall be substituted for a part of the gray Portland cement on exposed concrete in order to produce a colour matching the colour of the surrounding concrete, as determined by a trial patch.
- 8.2.3 The quantity of mixing water shall be no more than necessary for handling and placing. The patching mortar shall be mixed in advance and allowed to stand with frequent manipulation with a trowel, without addition of water, until it has reached the stiffest consistency that will permit placing.
- 8.2.4 After surface water has evaporated from the area to be patched, the bond coat shall be well brushed into the surface. When the bond coat begins to lose the water sheen, the premixed patching mortar shall be applied. The mortar shall be thoroughly consolidated into place and struck off so as to leave the patch slightly higher than the surrounding surface. To permit initial shrinkage, it shall be left undisturbed for at least 1 hour before being finally finished. The patched area shall be kept damp for 7 days. Metal tools shall not be used in finishing a patch in a formed wall which will be exposed.
- 8.2.5 Where as-cast finishes are specified, the quantity of patched area shall be strictly limited. The combined total of patched areas in as-cast surfaces shall not exceed 2 sq.ft. in each 1000 sq.ft. of as-cast surface. This is in addition to form tie patches, if the project design permits ties to fall within as-cast areas.
- 8.2.6 Any patches in as-cast architectural concrete shall be indistinguishable from surrounding surfaces. The mix formula for patching mortar shall be determined by trial to obtain a good colour match with the concrete when both patch and concrete are cured and dry. After initial set, surfaces of patches shall be dressed manually to obtain the same texture as surrounding surfaces.
- 8.2.7 Patches in architectural concrete surfaces shall be cured for 7 days. Patches shall be protected from premature drying to the same extent as the body of the concrete.

8.3 **Tie and Bolt Holes**

After being cleaned and thoroughly dampened, the tie and bolt holes shall be filled solid with patching mortar. If architectural appearance requires, these holes may be filled partially creating the desired round clear holes pattern on surfaces exposed to view.

8.4 **Proprietary Materials**

If permitted or required by the Engineer, proprietary compounds for adhesion or as patching ingredients may be used in lieu of or in addition to the foregoing patching procedures. Such compounds shall be used in accordance with the manufacturer's recommendations with prior approval of the Engineer.

9. **CONCRETE CONSTRUCTION TOLERANCES**

Where tolerances are not stated in the specifications or drawings for any individual structure or feature thereof, maximum permissible deviations from established lines, grades and dimensions shall conform to the following. The Contractor is expected to set and maintain concrete forms so as to ensure complete work within tolerance limits. These allowable tolerances shall not relieve the Contractor of this responsibility for correct fitting of indicated materials. These tolerances are not cumulative.

9.1 Variation from the plumb (or the specified batter for inclined walls.)

9.1.1 In the lines and surfaces of columns, piers, walls and in arrises:

In any 10 feet of length or height	1/4 inch
In any storey or 20 feet length	3/8 inch
Maximum for the entire length or height.	1 inch

9.1.2 For exposed corner columns, control joint grooves and other conspicuous lines.

In any bay or 20 feet maximum	1/4 inch
Maximum for the entire length or height	1/2 inch

9.2 Variation from the level or from the grades indicated on the drawings.

9.2.1 In floors, ceilings, beams soffits and in arrises measured before removal of supporting shores.

In any 10 feet of length	1/4 inch
In any bay or in any 20 feet length	3/8 inch
Maximum for the entire length	3/4 inch

9.2.2 For exposed lintels, sills, parapets, horizontal grooves and other conspicuous lines.

In any bay or 20 feet length	1/4 inch
Maximum for the entire length	1/2 inch

9.3 Variation of the linear building lines from established position in plan and related position of columns, walls and partitions.

In any bay or 20 feet of length	1/2 inch
Maximum for the entire length	1 inch

9.4 Variation in the sizes and locations of sleeves, floor openings and wall openings. ±1/4 inch

9.5 Variation in cross-sectional dimensions of columns and beams and in the thickness of slabs and walls.

Minus	1/4 inch
Plus	1/2 inch

9.6 **Footings**

9.6.1 Variation in dimensions in plan

Minus	1/2 inch
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Plus (plus variation applied to concrete only, not to reinforcing bars or dowels).	2 inch
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9.6.2	Misplacement or eccentricity	2 percent of the footing width in the direction of misplacement but not more than (applies to concrete only, not to reinforcing bars or dowels).	2 inch
9.6.3	Thickness	Decrease in specified thickness	5%
		Increase in specified thickness	No limit
9.7	Variation in Steps		
9.7.1	In a flight of stairs		
	Rise		$\pm 1/8$ inch
	Tread		$\pm 1/4$ inch
9.7.2	In consecutive steps		
	Rise		$\pm 1/16$ inch
	Tread		$\pm 1/8$ inch
9.8	<u>Tolerances for Precast concrete construction'</u>		

Forms must be true to size and dimensions of concrete members shown on the plans and be so constructed that the dimensions of the finished products will be within the following limits at the time of placement of these units in the structure, unless otherwise noted on structural-architectural drawings:

9.8.1	Overall dimensions of members		1/16 inch per 10 feet
9.8.2	Cross-sectional dimensions		
	Sections less than 3 inch.		1/16 inch
	Sections over 3 inch and less than 18 inch.		1/8 inch
	Sections over 18 inch.		1/4 inch
9.8.3	Deviations from straight line in long sections.		
	Not more than		1/8 inch per 10 feet.
9.8.4	Deviation from specified camber		$\pm 1/16$ inch per 10 feet span.
	Maximum differential between adjacent units in erected position		1/4 inch.

10. ACCEPTANCE OF STRUCTURE

10.1 General

10.1.1 Completed concrete work which meets all applicable requirements will be accepted subject to the other terms of the Contract Documents.

10.1.2 Completed concrete work which fails to meet one or more of the requirements and which has been repaired to bring it into compliance will be accepted subject to the other terms of the Contract Documents.

10.1.3 Completed concrete work which fails to meet one or more of the requirements and which cannot be brought into compliance may be accepted or rejected as provided in these Specifications or in the Contract Documents. In this event, modifications may be required to assure that remaining work complies with the requirements.

10.2 **Dimensional Tolerances**

10.2.1 Formed surfaces resulting in concrete outlines smaller than permitted by the tolerances of clause 9 shall be considered potentially deficient in strength and subject to the provisions of sub clause 10.4.

10.2.2 Formed surfaces resulting in concrete outlines larger than permitted by the tolerances of clause 9 may be rejected and the excess material shall be subject to removal. If removal of the excess material is permitted, it shall be accomplished in such a manner as to maintain the strength of the section and to meet all other applicable requirements of function and appearance. Permission is required if excess material is to be removed in accordance with this clause.

10.2.3 Concrete members cast in the wrong location may be rejected if the strength, appearance or function of the structure is adversely affected or if misplaced items interfere with other construction.

10.2.4 Inaccurately formed concrete surfaces exceeding the limits of Clause 9 or of Clause 5.6 of Section 'Formwork' and which are exposed to view, may be rejected and shall be repaired or removed and replaced if required.

10.3 **Appearance**

10.3.1 Architectural concrete with surface defects exceeding the limitations of Sub-clause 5.6 of Clause 5 of the Section, 'Formwork' shall be removed and replaced.

10.3.2 Other concrete exposed to view with defects which adversely affect the appearance of the specified finish may be repaired only by approved methods.

10.3.3 Concrete not exposed to view is not subject to rejection for defective appearance.

10.4 **Strength of Structure**

10.4.1 The strength of the structure in place will be considered potentially deficient if it fails to comply with any requirements which control the strength of the structure, including but not necessarily limited to the following conditions.

- Concrete strength requirements not considered to be satisfied in accordance with Clause 6 hereof.
- Reinforcing steel size, quantity, strength, position or arrangement at variance with the requirements as listed under specification of 'Reinforcement' or in the Contract Documents.
- Concrete which differs from the required dimensions or location in such a manner as to reduce the strength.
- Curing less than that specified.

- Inadequate protection of concrete from extremes of temperature during early stages of hardening and strength development.
 - Mechanical injury, construction fires, accidents of premature removal of formwork likely to result in deficient strength.
 - Poor workmanship likely to result in deficient strength.
- 10.4.2 Structural analysis and/or additional testing may be required when the strength of the structure is considered potentially deficient.
- 10.4.3 Core tests may be required when the strength of the concrete in place is considered potentially deficient.
- 10.4.4 If core tests are inconclusive or impractical to obtain or if structural analysis does not confirm the safety of the structure, load tests may be required and their result evaluated in accordance with British Standard BS 8110 or ACI Standard 318.
- 10.4.5 Concrete work judged inadequate by structural analysis or by results of a load test shall be reinforced with additional construction if so directed by the Engineer or shall be replaced, at the Contractor's expense.
- 10.4.6 The Contractor shall pay all costs incurred in providing the additional testing and/or analysis required by this section.
- 10.4.7 The Employer will pay all costs of additional testing and/or analysis which is made at his request and which is not required by these Specifications, or by the Contract Documents.

11. **PVC WATER STOP/HYDROFOIL**

11.1 **Material**

All PVC water stops/hydrofoil shall be central bulb type from a manufacturer approved by the 'Engineer'. The specific gravity of PVC water stop/hydrofoil shall not be less than 1.37 and Full stretch Break cut intensity when tested at normal temperature shall not be less than 1875 psi.

The material shall have a modulus of rigidity of 850 psi at +10° C and 10,500 psi at 20° C.

11.2 **Placing & Connections**

In general all PVC water stops/hydrofoil shall be placed in the centre of the structural member. Each piece of the water stop-hydrofoil shall be of maximum practicable length. An ordinary sharp knife, saw or any other sharp tool can be used to cut the water stop. Joints at inter sections and at ends of pieces shall be made in the manner most appropriate to the material being used. Joints shall develop effective water tightness fully equal to that of the continuous water stop material and shall permanently retain their flexibility. For straight line connection melting method of connection can be used by passing two water stops intended for connection against a heated iron or copper sheet. When they are melted, the two are combined.

After joining, the water stop should be allowed to cool.

For all other connections such as T-type or L-type, the welding method of joining should be used. Welding rod of same material as the water stop shall be used. The welding rod & the water stop shall be heated & melt at the same time, by means of heated air jetting from the hot jet gun.

12. **NON-SHRINK GROUT:**

Grout for placement under base and bearing plates of machinery and equipment, for grouting anchor bars and dowels and for similar uses shall be as follows:-

12.1 **Composition**

- 12.1.1 Non-shrink grout of less than 1 inch thickness shall consist of one part Portland cement and one part of clean sharp sand conforming to the requirements of these specifications and 1:22,000 to 1:15000 part of grained aluminum powder containing non polishing agent.
- 12.1.2 Non-shrink grout of 1 inch or more in thickness shall be proportioned as above except that 1-1/2 parts of 3/8 inch to 1/4 inch pea gravel shall be added.
- 12.1.3 The above specified composition may be varied if required by the Engineer. The Contractor shall, at his own cost, make optimum mix design and testing for approval of the composition.
- 12.1.4 Proportioning shall be done by weight.
- 12.1.5 Mixing water shall be proportioned so as to provide a flowable mixture without segregation or bleeding. Dry packing will not be permitted.

12.2 **Application**

- 12.2.1 Concrete surfaces to receive non-shrinking grout shall be roughened, cleaned and dampened.
- 12.2.2 Form shall be provided to retain the grout until sufficiently hard to support itself.
- 12.2.3 Grout shall be poured in place and thoroughly rodded or washed to prevent the formation of voids.
- 12.2.4 After non-shrink grout has received its initial set, it shall be kept damp for 24 hours.

12.3 **Non-Shrink Second Stage Concrete Grout**

Non-shrink second stage concrete grout shall be provided and placed in position where shown on the Drawings or as directed by the Engineer. Non-shrink concrete mix proportion shall be one part cement two parts coarse clean sand and four parts of coarse aggregates meeting the requirements of these specifications and 1:22,000 to 1:15000 part of grained aluminum powder containing non-polishing agent. Proportioning shall be done by weight.

The above specified composition may be varied if required by the Engineer.

The Contractor shall at his own cost make optimum mix design and testing for approval of the Engineer prior to commencement of the work.

Mixing water and application procedure shall be followed as given in sub-clause 12.2 or as per direction of the Engineer.

13. **VAPOUR BARRIER**

Vapour barrier shall be polyethylene building film, visqueen standard or approved equal. The film shall be 150 micron thick (100 gauge). The quality of material shall be approved by the Engineer prior to use in the works.

Vapour barrier shall be laid in position wherever shown on the Drawings.

The material shall be supplied in rolls and laid by rolling over the prepared surface at the levels and position in the areas shown on the Drawings. Where joint is necessary at the side or end of a sheet, this shall be a double weld folded joint made by placing the edges together and folding over twice continuously taking the top edge prior to concreting. The Contractor shall protect the film sheets from damages during laying and subsequent operations and shall replace at his own cost all damaged film sheets to the satisfaction of the Engineer.

Manufacturer's recommendations and instructions along with the sample of material shall be submitted to the Engineer for his approval.

14. MEASUREMENT AND PAYMENT

14.1 General

Except otherwise specified herein or elsewhere in the Contract Documents, no measurement and payment will be made for the under mentioned specified works related to the relevant items of the Bills of Quantities. The cost thereof shall be deemed to have been included in the quoted unit rate of the respective items of the Bills of Quantities.

The rates quoted by the Contractor in the Bill of Quantities shall include work to be executed under these specification in any floor and at any height except where otherwise specifically stated in the relevant item of Bill of Quantities and the Contractor shall not be entitled to any claim or claim any compensation on this account.

14.1.1 Providing, fixing, striking, etc. of formwork.

14.1.2 Providing, placing and fixing of anchor bolts or any other embedded parts.

14.1.3 Providing and installing all type of joints in concrete structure, including expansion joints.

14.1.4 Providing and fixing water stoppers.

14.2 Plain and Reinforced Concrete

14.2.1 Measurement

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

- Volume of any steel embedded in the concrete.
- Volume occupied by water pipes, conduits etc. not exceeding 10 square inches each in cross-sectional area.
- Voids not exceeding 4 square inch in work given in square feet. If any void exceeds 4 square inch, total void shall be deducted.

Voids, which are not to be deducted as specified above, refer only to openings or vents which are wholly within the boundaries of measured areas. Openings or vents which are at the boundaries of measured areas shall always be subject to deductions irrespective of size.

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

Junction between straight and curved works shall in all cases be deemed to be included with the work in which they occur.

Measurement of walls shall be taken between attached columns piers or pilaster. The thickness of attached columns, piers or pilaster shall be taken as the combined thickness of the wall and the columns, piers or pilaster.

Attached or isolated columns, piers, pilaster, and the like (except where caused by openings) having a length on plan not exceeding four times the thickness shall be classified as columns. Those having a length over four times the thickness and are caused by openings in wall shall be classified as walls.

Columns shall be measured from the top of footing/footing beams or floor surfaces to the underside of beams or slabs as the case maybe. Where the width of beams is less than the width of columns, the extra width at the junction shall be included in the beams.

The depth of the beams shall be measured from bottom of the slab to the bottom of the beams except in case of inverted beams where it shall be measured from top of slab to the top of beam. The cross-section of the beam shall be the actual cross-section below or above the slab.

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

14.2.2 Payment

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

14.3 Testing of Material

- a) A site laboratory shall be established by the Contractor for all the required testing of concrete, aggregates and other materials etc. All tests shall preferably be done at site. Only the test which are not possible to be carried out in the site laboratory shall be referred to the laboratory approved by the Engineer. All testing charges thereof shall be borne by the Contractor.

For testing of reinforcement steel bars, the samples shall be referred to the laboratory approved by the Engineer at the cost of the Contractor.

- b) Cement shall be tested as prescribed in ASTM C -150.
- c) Aggregates shall be tested as prescribed in British Standard BS 812 & 882. In addition fine aggregate shall be tested for organic impurities in conformance with ASTM Standard C.40.

14.4 Vapour Barrier

14.4.1 Measurement

Measurement of acceptably completed works of vapour barrier will be made on the basis of number of square feet provided and placed in position as shown on the Drawings or as directed by the Engineer.

14.4.2 Payment

Payment will be made for the acceptable measured quantity of vapour barrier on the basis of unit rate per square feet quoted in the Bill of Quantities and shall constitute full compensation for all the works related to the item.

Endo of Section 2300

SECTION - 3000
STRUCTURAL STEEL WORKS

- 1. SCOPE**
- 2. APPLICABLE CODES AND STANDARDS**
- 3. MATERIALS**
- 4. CONNECTIONS**
- 5. ALLOWABLE STRESSES**
- 6. SHOP DRAWINGS**
- 7. FABRICATION**
- 8. WELDER QUALIFICATIONS**
- 9. WELDERS IDENTIFICATION**
- 10. TEST ASSEMBLY**
- 11. SURFACE PREPARATION AND PAINTING**
- 12. INSPECTION AND TESTS**
- 13. ERECTION**
- 14. MEASUREMENT AND PAYMENT**

SECTIONS – 3000

STRUCTURAL STEEL WORKS

1.0 SCOPE

The work under this section consists of furnishing all material, labour, plant, equipment and appliances, fabricating, erecting, installing, testing, painting and all other items incidental to steel work for a complete job as shown on the drawings, specified herein and/or as directed by the Engineer.

2.0 APPLICABLE CODES AND STANDARDS

Latest edition of the following codes and standards are applicable to the work of this section:

AISC Specifications for the design, fabrication and erection of structural steel for buildings.

ANSI / AISC 360 Manual of steel construction, LRFD & ASD.

AISC 303 Code of Standard Practice, for Steel Buildings and Bridges.

AISC Specifications for structural joints using ASTM A325 or A490 bolts.

AISC Guide to shop painting of Structural Steel.

ASTM A6 Standard specifications for general requirements for rolled steel plates, shapes, sheets, piling and bars for structural use.

ASTM A36 Standard Specifications for Carbon Structural Steel.

ASTM A53 Standard Specifications for Pipe, Steel, Black & Hot Dipped, Zinc Coated, Welded and Seamless

ASTM A307 Carbon steel externally and internally threaded standard fasteners.

ASTM A325 High strength bolts for structural steel joints including suitable nuts and plain hardened washers.

ASTM A446 Specifications for steel sheet zinc coated (galvanized) by the hot dipped process.

ASTM A490 Quenched and tempered alloy steel bolts for structural steel joints.

ASTM A501 Hot formed welded and seamless carbon steel structural tubing.

ANSI / NAAMM Metal Bar Grating
MBG 531

ASTM A563 Carbon and alloy steel nuts.

ASTM A572 Standard Specifications for High - Strength Low - Alloy Columbium – Vanadium Structural Steel

ASTM E109 Dry powder magnetic particle inspection.

AWS D1.1 Specifications for welding of steel structures.

ANSI
B 18.2.2.1 Plain Washers.

SSPC – SP6 Steel structures painting council – surface preparation specifications.

3.0 **MATERIALS**

Except otherwise stated on the drawings, the material specifications shall conform to the following. Wherever necessary the Contractor may use equivalent alternative material subject to approval of the Engineer.

3.1 **Structural Steel**

- Structural steel shall conform to the requirements of ASTM A-36, or ASTM A-572.
- Steel pipes shall conform to the requirements of ASTM A 53 Class B, ASTM A501 or shall be made of plates spirally welded.
- All material shall be supplied chirpy V-Notch testing in accordance with ASTM A6, Supplementary Requirement S5.
- Grating shall conform to ANSI / NAAMM MBG 531.

3.2 **Welding**

Welding electrodes shall match the base metal and shall conform to the requirements of AWS D1.1 specifications.

3.3 **High Strength Bolts**

All shop connections, except as noted herein or on the drawings, shall be made with High Strength Bolts in friction type connections, or by welding.

High strength bolts, heavy hexagonal nuts and hardened washers shall conform to the requirements of ASTM A325. All field connections, except noted, shall be made with high strength bolts in friction type connection.

3.4 **Washers**

Washers shall conform to the requirements of ANSI B18.2.2.1 and shall be of structural grade steel appropriate for the type of bolts for which they are used. For oversized holes, the washers shall be large enough to cover the entire hole by at least 6mm (1/4 in.) or as directed by the Engineer.

3.5 **Studies**

Steel Studies Shear Connectors shall conform to the requirements of Structural Welding Code-Steel, AWS D1.1.

4.0 **CONNECTIONS**

All connections shall be designed and detailed for 75% of the effective capacity of the member. A minimum of two bolts or equivalent welding shall be used per connection.

Shop connection may be welded or bolted. Field connections shall be bolted unless noted otherwise on design drawings or approved by the engineer.

5.0 ALLOWABLE STRESSES

Allowable design stresses for structural steel members and their connections, including temporary bracings and shorings shall be in accordance with AISC Specifications.

6.0 SHOP DRAWINGS

- 6.1 Shop drawings shall be submitted by the Contractor, for structural steel works, for acceptance in accordance with the requirements or the Contract Documents.
- 6.2 Shop drawings furnished for this section shall conform to the best standards of the construction industry. Shop drawings shall be prepared by and under the supervision of competent engineering personnel. Prior to submittal, the Contractor shall check each shop drawing for compliance with the requirements of the Contract Documents.
- 6.3 Shop drawings shall include plans, elevations, sections and complete details to describe clearly, at an ample scale, all work to be provided. Drawings shall be accurately dimensioned and shall be noted clearly.
- 6.4 All connections shall be designed and detailed as, per sub-section 4 above, by the contractor on the shop drawings. Design calculations for connections shall be made as per AISC specifications and shall be submitted along with the shop drawings after checking and signing by the Contractor for approval of the Engineer.
- 6.5 The shop drawings shall include
- (i) An erection scheme, in suitable size, having the following information:
- Location of erection elements in respect of axis and Marks as well as picking points of these elements with respect to each other or with the existing steel or reinforced concrete structures.
 - Joints showing erection welding sizes and lengths, bolts diameter and numbers.
 - Chart showing list of assembling marks having columns such as Mark, Description, Quantity, Weight of each Mark, total weight and Remarks with grand total in the end.
 - Chart showing List of Erection Bolts, Nuts and Washers in tabulated form, detailing information such as size, quantity, weight and their grand totals.
 - Quality of materials.
 - Quality and type of welding electrodes.
 - Measures to be adopted against unscrewing of bolts.
 - Painting instructions.
 - Erection sequence.
 - References to relevant drawings.

- Except in special cases all scheme drawings shall be made in single fairly thick lines.
 - The recommended scale of erection scheme is 1:50, 1:100, 1:200, for joints 1:5, 1:10 or 1:20.
- (ii) Fabrication drawings in suitable size shall contain the following information:
- Each Shop Assembly (Mark) shall be drawn separately showing necessary lines, elevations, sections with reference to axis, center lines, location of holes, cleats, plates, lugs etc. fully dimensioned with part numbers.
 - Bolts and holes sizes.
 - Welding symbols and welded joints requirements, in accordance with AISC manual of steel construction and AWS specifications.
 - Geometrical Setting out dimensions necessary for the assembly of an element. Location and details of joints as calculated by the Contractor.
 - Instruction for welding, dimensions of weld, edge preparations methods of welding, and methods for control of distortions.
 - List of symbols for bolts and holes uses.
 - List of symbols for welds used.
 - Edge distance (general).
 - Welding sizes and lengths (general).
 - Standards and quality of materials.
 - Type and quality of welding electrodes.
 - Tests for welding.
 - Reference to related erection scheme drawings.
 - Reference to design and working drawings.
 - Part list.
 - Instructions for surface preparation, painting, primer and finish coats.

Recommended scales for fabrication drawings are preferably 1:10 or 1:20, and for joints and details 1:1, 1:2, or 1:5.

7.0 FABRICATION

The Contractor shall notify the Engineer about any problems or doubts/errors, if any, in the drawings for clarifications/rectification well in time to prevent any fabrication errors. Fabrication shall not be commenced until approval has been obtained from the Engineer.

7.1 **Straightening of Material**

Rolled material, before being worked upon shall be straightened within tolerances as per ASTM specifications A6. Straightening, necessarily shall be done by mechanical means or by the application of a limited amount of localized heat. The temperature of heated areas, as measured by approved methods, shall not exceed 1200 ° F.

7.2 **Cutting**

As far as practicable cutting shall be done by shearing. Oxygen cutting shall be done where shear cutting is not practicable and shall preferably be done by Machine. All edges shall be free from notches or burs. If necessary, the same shall be removed by grinding.

7.3 **Holes Punching/Drilling**

Holes shall be punched where thickness of the material is not greater than the diameter of bolt + 3mm (+ 1/8 in.). Where the thickness of the material is greater the holes shall either be drilled or sub-punched and reamed to size. The die for all sub-punched holes and the drill for all sub-drilled holes shall be at least 2mm smaller than the nominal diameter of the rivet or bolt.

7.4 **Welding**

7.4.1 All execution and inspection of welding shall be done in accordance with the provisions of the American Welding Society Specifications. No welding for piping/electrical supports shall be made transversely to any tension flanges or beams or columns.

7.4.2 Maximum and minimum size and lengths of fillet welds shall be in accordance with AISC specifications, or as mentions on drawing.

7.4.3 Surface to be welded shall be free from loose scale, slag, rust, grease, paint or any other foreign matter.

7.4.4 Butt welds shall be full penetration welds, unless otherwise specified and permitted.

7.4.5 Avoid the use of temporary welded attachments during fabrication as much as possible. After fabrication is completed, remove flush with the base material without encroaching on the minimum required base material thickness. After the surface has been restored, examine all areas from which temporary attachments have been removed by the same methods required for permanent fillet welds.

7.4.6 Do not begin structural welding until joint elements are tacked in intimate contact and adjusted to dimensions shown with allowance for any weld shrinkage that is expected. Weld heavy sections and those having a high degree of restraint with low hydrogen type electrodes. No member shall be spliced without approval.

7.4.7 For notch-toughness specified material, all weld metal, processes and preheat requirements shall be compatible to assure notch-tough composite weld metal.

7.4.8 Shop splices of webs and flanges in built-up girder shall be made before the webs and flanges are joined to each other.

7.5 Tolerances

Tolerances for Structural Steel be as per AISC Specifications unless noted otherwise.

8.0 WELDER QUALIFICATIONS

- 8.1 All welders contracted to perform work shall be required to show written evidence that they have been properly tested in compliance with the approved welding procedures.
- 8.2 Welders shall have been qualified in the proposed procedure by an established laboratory acceptable to the Engineer within the preceding 90 days.
- 8.3 All welders shall be qualified for the type of weldment, grade of steel, thickness of steel, welding process and welding position that they are employed to weld. Welders and welding operators that have not been performance qualified, for all material and thickness ranges used on the job, shall be restricted to welding only that portion of the work for which they are qualified.
- 8.4 Engineer reserves the right to have welders or welding operators requalified or removed from the job as he deems necessary during the progress of work. Engineer's decision regarding the qualifications of any welder shall be final.

9.0 WELDERS IDENTIFICATION

- 9.1 Each welder shall be assigned a unique identifying number or symbol that he shall use to identify all welding resulting from his skills.
- 9.2 Stenciled markings shall be applied within 40mm (1-5/8 in.) of the weld using low stress concentration dies. Written symbols are also acceptable.
- 9.3 A record shall be kept of these symbols by the Contractor. The records shall show welder's name, symbol assigned, procedures to which qualified, employment and test dates. This record shall be available to the Engineer's Representative at all times.

10.0 TEST ASSEMBLY

- 10.1 Fabricated components such as Beams Girders, Bracing, as and where required by planning, shall be test assembled in the shop prior to transportation to site.
- 10.2 Test assembly work and procedure should be planned during fabrication process.
- 10.3 Each test assembly shall be got inspected from the Engineer's Representative and shall be dismantled only after his approval in writing.

11.0 SURFACE PREPARATION AND PAINTING

Surface preparation and painting shall be in accordance with the provisions of the Code of Standard Practice of the American Institute of Steel Construction, Inc.

11.1 Surface Preparation

- a) All steel shall be cleaned free from loose scale, rust, burrs slag, etc. by means of sand blasting and/or other approved means as recommended by the manufacturer of paint.
- b) The sand used for this purpose shall conform to the type as specified in SSPC-SP.6. It should be free from earth, dust, clay and moisture. For this, the Contractor shall submit the gradation (no less than that passing through a 16 mesh screen U.S. sieve series) and source of sand along with the sample for approval by the Engineer prior to commencing the sand blasting operation.
- c) The size of sand particles, air pressure and size of the hose nozzle shall be correlated to give proper and acceptable surface.
- d) Material which is to be used for fabrication of components to be galvanized later on shall not be cleaned (See clause 11.3).

11.2 Painting

- a) After fabrication, assembly and surface preparation all assembled units shall be given two shop coats of epoxy primer and two coats of epoxy enamel paint in the fabrication shop.
- b) One final coat of epoxy enamel paint shall be applied after erection of all components.
- c) The thickness of each coat of paint shall be in accordance with the paint manufacturer's recommendation.
- d) All other requirements for the specified paint system shall be in accordance with the paint manufacturer's specifications/ recommendations.
- e) The type of primer & paints to be applied shall be as specified in clause 11.2.1.
- f) The Contractor shall use the best quality of the type of paint specified and shall get the same approved by the Engineer.
- g) Steel work/Surfaces not to be painted
 - i) Steel work to be encased/embedded in concrete or surface in contact with concrete or grout shall not be painted, but shall be given a cement wash after surface preparation.
 - ii) Machined finished surfaces shall not be painted but shall be coated with rust preventive compound, approved by the Engineer immediately after finishing. Such surfaces shall also be protected with wooden pads or other suitable means for transportation. Unassembled pins, keys, and bolt thread shall be greased and wrapped with moisture resistant paper.
 - iii) Contact surfaces of connections using high strength bolts in friction type connections shall not be painted. Such surfaces of all components after fabrication shall be cleaned free of paint. No coating whatsoever then shall be applied to such surface. The surface roughness for high strength friction grip bolts is a

very important factor therefore components shall not be erected unless approved by the Engineer.

11.2.1 **Primer and Paint**

11.2.1.1 **Primer:**

Primer shall be epoxy primer of a proven quality. The type of primer to be used shall be approved by the Engineer.

11.2.1.2 **Paint:**

Paint shall be epoxy enamel of a proven quality. The type of paint to be used shall be approved by the Engineer.

11.3 **Galvanizing (Zinc Coating)**

Galvanizing, wherever specified, shall be applied in a manner and of a thickness and quality conforming to the requirements of ASTM A123 standard specifications for zinc (Hot galvanized) coating on products fabricated from rolled, pressed and forged steel shapes, plates, bars and strips.

Components shall be galvanized i.e. zinc coated after complete fabrication i.e. welding, drilling etc. the process shall consist of removal of rust and mill scale by pickling in hydrochloric acid or sulphuric acid followed by water wash and prefluxing in tanks containing zinc ammonium chloride and then fluxing with ammonium chloride. The fluxed components shall then be passed through a drying oven prior to immersion in a bath of virtually pure molten zinc.

12.0 **INSPECTION AND TESTS**

- 12.1 Manufacturer's Test Certificate for all material used shall be furnished by the Contractor for Engineer's scrutiny and approval.
- 12.2 Rolling tolerance of all shapes and profile according to AISC shall be in accordance with the provisions of ASTM A6 specifications. These shall be checked by the Contractor before commencing work and shall be rejected if found not within limits.
- 12.3 Materials shall be tested for conformance with the specified standards at an approved testing laboratory as and when directed by Engineer.
- 12.4 Contract surfaces of connections using high strength bolts in friction type connections shall be got inspected and approved from the Engineer before bolting.
- 12.5 All bolted connections shall be got inspected and approved from the Engineer for types, size, number of bolts and installation including tightening.
- 12.6 Inspection and Testing - Welding

12.6.1 **General**

Welding shall be inspected and tested by an approved testing laboratory during fabrication and erection of structural steel as follows:

The testing laboratory shall be responsible for conducting and interpreting the tests. It shall state in each report whether or not the test

specimens conform to all requirements of the Contract Document and shall specifically note any deviations therefrom.

Certify all welders and make 100 percent visual inspections and tests as follows:

- Record types and locations of all defects found in the welding work.
- The measures required and performed to correct such defects.

In addition to the requirements of AWS D 1.1, paragraph 8.15, each weld shall be visually free of slag, inclusions and porosity.

In addition to visual inspection of all welds magnetic particle, ultra-sonic and radiographic inspection shall be made of all welds as specified below. Magnetic particle tests shall be made on the root pass and finished weld.

The method of magnetic particle test shall be in accordance with ASTM E109. Any type of crack or zone of in-complete fusion or penetration shall not be acceptable.

Radiographic testing technique and standards of acceptance shall be in accordance with AWS D 1.1.

Ultra-sonic testing shall be performed in accordance with AWS D 1.1.

Welding inspection and test report showing evidence of the quality of welding shall be submitted by the Contractor. For each section of weld inspected and tested, furnish a report which clearly identifies the work, the welder's identification, the areas of inspections and test, the acceptability of the welds, and signature of the inspector or laboratory incharge. Each report shall be completed at the time of inspection or test. For radiographic examination, furnish a complete set of radiographs in addition to the reports. All inspection and testing shall be carried out in presence of the Engineer or his representative.

12.6.2 Test Methods

Use the following test methods as specified. The following list is in descending order. When a particular test method is specified for a joint and the method is impractical to use, use the next highest method practicable. The alternative method will be subject to approval, NDT procedures and techniques shall be in accordance with AWS D 1.1, section 6.7.

- a) Radiographic Method: In addition to the requirements of AWS D 1.1, comply with ASTM E94.
- b) Ultrasonic method.
- c) Magnetic particle method.
- d) Liquid Penetration Method: Visible-dye, solvent removable method only.

12.6.3 Members Designated for Tests

- a) Built – up Members:

Examine 100 percent of flange-to-flange and web-to-web welding by the radiographic method. For all web-to-flange and pipe column seam welding, examine ten percent of each welder's work as follows:

- Full penetration groove welds by the ultrasonic.
- fillet welds and partial penetration groove welds by the magnetic particle method.

b) Moment Connection Joints:

- Examine 100 percent of all flange-to-flange and web-to-web welding as follows:

Full penetration groove welds by the ultrasonic method or other method as designated by the Engineer.

Fillet welds and partial penetration groove welds by the magnetic particle method.

- For all web-to-flange welding, examine ten percent of each welder's work as follows:

Full penetration groove welds by the ultrasonic method or radiographic method as approved by the Engineer.

Fillet welds and partial penetration groove welds by the magnetic particle method.

c) Column Base Plates.

Examine 100% of all welding for connection of base plate to column.

d) Bracing Connections: Examine 100 percent of all welding for connection of diagonal bracing as follows:

- Groove welds by the ultrasonic method.
- Fillet welds by the magnetic particle method.

12.6.4 Requirement for ten percent Examination

- a) Examine a 300mm (12 in.) section of weld in each 3m (10 ft.) increment of each welder's work as directed by the Engineer. If the examination meets the acceptance standards of AWS D 1.1, the 3m (10 ft.) of weld represented will be accepted.
- b) if the examination fails to meet the acceptance standards, examine two additional 300mm (12 in.) sections in the 3m (10 ft.) increment as directed by the Engineer. If both of these examinations meet the acceptance standards, the 3m of weld represented will be accepted. Repair the defects detected in the first examination and re-examine.
- c) If one or both of the examinations fails to meet the acceptance standards, examine the remaining weld of the 3m (10 ft.) increment. Repair the areas that do not meet the acceptance standards and re-examine.

12.6.5 Repair and Re-Testing of Welds

Repair defective welds in accordance with AWS D 1.1, or replace the weld, and Re-test repaired and replaced welds by the same method and acceptance standard used to examine the original weld. In addition, when defective welds are found, the testing laboratory shall determine the cause of the defective welding and institute immediate corrective action.

All defective welding shall be repaired or replaced at the Contractor's expense.

12.7 Rejection

Neither the fact that the materials have been tested nor that the manufacturers test certificates have been furnished shall effect the liberty of the Engineer to reject material found not according to these specifications.

Materials or workmanship not in conformance with the provisions of these specifications shall be rejected at any time, after delivery or during the progress of the work or the completion and erection at site.

13.0 ERECTION

13.1 Bracing

All steel structures shall be carried up true and plumb within the limits defined in the AISC code of standard practice, and temporary bracing shall be introduced wherever necessary to take care of all construction loads to which the structure may be subjected including the equipment and the operation of the same. Such bracing shall be left in place as long as required for safety.

Wherever piles of materials, erection equipment and other loads are carried during erection, proper provision shall be made by the Contractor to take care of the stresses resulting from such loads.

13.2 Alignment

No permanent bolting or welding shall be done at site during erection until as much of the structure as will be stiffened thereby has been properly aligned and approved by the Engineer.

13.3 Joints Using High Strength Bolts

All structural joints using high strength bolts shall be executed and inspected in accordance with "AISC Specification for structural joints using ASTM A325 or A490 bolts". High strength bolts and nuts, loosened after tightening, shall be discarded and replaced with unused bolts and nuts.

14.0 MEASUREMENT AND PAYMENT

14.1 General

Except otherwise specified herein or elsewhere in the Contract Documents, no measurement and payment will be made for the under mentioned specified works related to the relevant items of the Bill of Quantities. The cost there of shall be deemed to have been included in the quoted unit rate of the respective items of the Bill of Quantities.

14.1.1 Nuts, bolts, screws, washers, weld metal and welding rods.

14.1.2 Testing of materials and welds, and repair of defects.

14.1.3 Surface preparation including cleaning with sand blasting.

14.1.4 Painting system including primer coats.

14.1.5 Galvanizing

14.1.6 Fabrication

14.1.7 Erection

14.2 **Structural Steel Works**

14.2.1 Measurement

Measurement of acceptably completed works of structural steel will be made on the basis of weight in kilogram, according to approved shop drawings, after verification at site to the satisfaction of the Engineer that the items fabricated, supplied and erected in position conform with the contract and approved shop drawings.

14.2.2 Payment

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

14.3 **MS Railing**

14.3.1 Measurement

Measurement of acceptably completed works of MS railing will be made on the basis of actual length in running meter/ running foot, according to approved shop drawings, after verification at site to the satisfaction of the Engineer that the items fabricated, supplied and erected in position conform with the contract and approved shop drawings.

14.3.2 Payment

Payment will be made for acceptable measured quantity of MS railing works on the basis of unit rate per running meter / running foot quoted in the respective items of Bill of Quantities and shall constitute full compensation for all the works related to the item.

14.4 **Steel Door**

14.4.1 Measurement

Measurement of acceptably completed works of Steel door will be made on the basis of net actual area in square meter / square foot, according to approved shop drawings, after verification at site to the satisfaction of the Engineer that the items fabricated, supplied and erected in position conform with the contract and approved shop drawings.

14.4.2 Payment

Payment will be made for acceptable measured quantity of Steel door on the basis of unit rate per square meter / square foot quoted in the respective items of Bill of Quantities and shall constitute full compensation for all the works related to the item.

14.5 **Steel Grating**

14.5.1 Measurement

Measurement of acceptably completed works of Steel grating will be made on the basis of number of gratings, according to approved shop drawings, after verification at site to the satisfaction of the Engineer that the items fabricated, supplied and erected in position conform with the contract and approved shop drawings.

14.5.2 Payment

Payment will be made for acceptable measured quantity of Steel grating on the basis of number of gratings quoted in the respective items of Bill of Quantities and shall constitute full compensation for all the works related to the item.

14.6 **Steel Gate**

14.4.1 Measurement

Measurement of acceptably completed works of Steel Gate will be made on the basis of number of Gates, according to approved shop drawings, after verification at site to the satisfaction of the Engineer that the items fabricated, supplied and erected in position conform with the contract and approved shop drawings.

14.4.2 Payment

Payment will be made for acceptable measured quantity of Steel Gate on the basis of number of Gates quoted in the respective items of Bill of Quantities and shall constitute full compensation for all the works related to the item.

*** End of Section 3000 ***

SECTION - 6700

PAINING

- 1. SCOPE**
- 2. APPLICABLE STANDARDS**
- 3. GENERAL**
- 4. MATERIALS**
- 5. DELIVERY, STORAGE AND CONTAINER SIZES**
- 6. SURFACE PREPARATION**
- 7. APPLICATION**
- 8. JOB CONDITIONS**
- 9. QUALITY ASSURANCE**
- 10. SCHEDULE OF MEASUREMENT OF PAINT AREA**
- 11. MEASUREMENT AND PAYMENT**

SECTION - 6700

PAINTING

1.0 SCOPE

The work under this section of the Specifications consists of furnishing all materials, plant, labour, equipment, appliances and performing all operations in any floor and at any height in connection with surface preparation, mixing, painting concrete works, gates, frames, walls, ceilings and all such surfaces as shown on the Drawings and/or as directed by the Engineer. The scope of this section of specification is covered with detailed specifications as laid down herein.

2.0 APPLICABLE STANDARDS

Latest editions of following British Standards are relevant to these specifications wherever applicable.

2.1 BSI (British Standards Institution)

- 245 Specification for mineral solvents (white spirits and related hydrocarbon solvents) for paints and other purposes.
- 2521 Lead-based priming paint for wood work.
- 2523 Lead based priming paint for iron and steel.
- 2569 Sprayed metal coatings.
- 4800 Paint colours for building purposes.
- CP.231 Painting of building.
- CP.3012 Cleaning and preparation of metal surfaces.

3.0 GENERAL

- 3.1 Except as otherwise specified, all painting shall be applied in conformity with BS CP 231 "Painting of Building" as applicable to the work.
- 3.2 The Contractor shall repair at his own expense all damaged or defective areas of shop-painted metal work and structural steel work. Metal surfaces against which concrete is to be placed will be furnished shop-painted and shall be cleaned prior to being embedded in concrete.
- 3.3 Except as otherwise specified all concrete and plastered surfaces are to be painted.
- 3.4 The Engineer will furnish a schedule of colours for each area and surface. All colours shall be mixed in accordance with the manufacturer's instructions.
- 3.5 Colours of priming coat (and body coat) where specified, shall be lighter than those of finish coat. The Engineer shall have unlimited choice of colours.
- 3.6 Samples of all colours, and finishes shall be prepared in advance of requirement so as not to delay work and shall be submitted to the Engineer for approval before any work is commenced. Any work done without such approval shall be redone to the Engineer's satisfaction, without additional expense to the Employer. Samples of each type of paint shall be on separate 12" x 12" x 1/8" tempered hard board panels. Manufacturer's colour chart shall be submitted for colour specifications and selection.

4.0 **MATERIALS**

- 4.1 All materials shall be acceptable, proven, first grade products and shall meet or exceed the minimum standards of reputable manufacturers as approved by the Engineer.
- 4.2 Colours shall be pure, non-fading pigments, mildew-proof sun-proof, finely ground in approved medium. Colours used on-plaster and concrete surfaces shall be lime-proof. All materials shall be subject to the Engineer's approval.
- 4.3 All synthetic enamel paints and primers for structural steel works, metal work and wood works will be the best available of its type and shall be approved by the Engineer prior to its procurement.
- 4.4 Approved quality Weather Shield/Weather Coat paint shall be used for painting the exteriors of the structures or other surfaces where specified on the drawings as directed by the Engineer.
- 4.5 The plastic emulsion paint, vinyl emulsion paint or similar as approved by the Engineer shall be used for interior surfaces.
- 4.6 Texture coating wherever specified shall be acrylic resin based coating composed of acrylic copolymers, natural quartz, natural marble chips, metallic oxides, antibacterial and antifungal additives, and expanders, foaming and setting agents and shall be applied in accordance with approved manufacturer's recommendations.
- 4.7 Only paints manufactured by ICI, Berger, Nippon Paints or approved equivalent shall be used in this Project.
- 4.8 All material shall be delivered to site in their original unbroken containers or packages & bear the manufacturer's name, label, brand & formula & will be mixed and applied in accordance with his directions.

5.0 **DELIVERY STORAGE AND CONTAINER SIZES**

Paints shall be delivered to the site in sealed containers, which plainly show the type of paint, colour (formula or specifications number) batch number, quantity, date of manufacture, name of manufacturer and instructions for use. Pigmented paints shall be supplied in containers not larger than 20 liters. All materials shall be stored under cover in a clean storage space, which should be accessible at all times to the Engineer. If storage is allowed inside the building, floors shall be kept clean and free from paint spillage.

6.0 **SURFACE PREPARATION**

- 6.1 All oil, grease, dirt, dust, loose mill scale and any other foreign substance shall be removed from the surface to be painted, polished and white washed by the use of a solvent and clean wiping material. Following the solvent cleaning, the surfaces shall be cleaned by scrapping, chipping, blasting, wire brushing or other effective means as approved by the Engineer.
- 6.2 In the event the surfaces become otherwise contaminated in the interval between cleaning and painting, re-cleaning will be done by the Contractor at no additional cost.
- 6.3 Surfaces of stainless steel, aluminum, bronze, and machined surfaces adjacent to metal work being cleaned or painted shall be protected by effective masking or other suitable means, during the cleaning and painting operations.
- 6.4 All the surfaces to be painted with approved quality paint shall be free from dust, dirt, fungus, lichen, algae etc. Oil paint, varnish and lime wash should always be removed by scraping and washing.

- 6.5 All surfaces to be bitumen painted shall be thoroughly cleaned of any accretion, dust, dirt etc. by scraping, wire-brushing or as directed by the Engineer. The surface shall be primed with a coat of asphalt oil used at the rate of not less than 0.50 pound per square foot.

No work in this section shall be allowed until all surfaces or conditions have been inspected and approved by the Engineer.

7.0 APPLICATION

- 7.1 All paint and coating materials shall be in a thoroughly mixed condition at the time of application. All work shall be done in a workman like manner, leaving the finished surface free from drips, ridges, waves, laps, and brush marks. All paints shall be applied under dry and dust free conditions. Unless approved by the Engineer paint shall not be applied when the temperature of the metal or of the surrounding air is below 7 degrees Centigrade. Surfaces shall be free from moisture at the time of painting.

All primary paint shall be applied by brushing. The first coat of paint shall be applied immediately after cleaning. When paint is applied by spraying, suitable measures shall be taken to prevent segregation of the paint in the container during painting operation.

Effective means shall be adopted for removing all free oil and moisture from the air supply lines of the spraying equipment. Each coat of paint shall be allowed to dry or harden thoroughly before the succeeding coat is applied. Surfaces to be painted that will be inaccessible after installation shall be completely painted prior to installation.

Coats of Weather Shield/Weather Coat paint shall be applied in accordance with the manufacturer's instructions or as directed by the Engineer.

Only as much material should be mixed as can be used up in one hour. Over-thinning will not be permitted. After the first coat the surfaces will be soaked evenly four or five times and the second coat shall be applied after leaving for at least overnight.

- 7.2 Where shown on Drawings all exterior finishes shall be painted with Weather Shield/weather coat paint or acrylic based textured coating (graffito) as shown on drawings in approved colours as per manufacturer's specifications. The number of coats shall be as shown on the drawings or as directed by the Engineer.

- 7.3 Plastic emulsion paint, vinyl emulsion paint or matt enamel paint of the approved make and shade shall be applied to surfaces as shown on Drawings as per manufacturer's instructions. The number of coat shall be as indicated on the Drawings or as directed by the Engineer.

8.0 JOB CONDITIONS

- 8.1 Observe manufacturer's recommended minimum and maximum temperature but do not apply paint or finish to any surface unless ambient temperature is 10 degree C or above and less than 43 degree C. No painting shall be done above 90% relative humidity.

- 8.2 Place drop cloths to adequately protect all finished work.

- 8.3 Remove and replace all items of finish hardware, device plates, accessories, lighting fixtures or other removable items.

- 8.4 In no case shall any finish hardware or other finished item that is already fitted into place be painted, unless otherwise specified.

9.0 **QUALITY ASSURANCE**

All paint for any one surface shall be top quality, of one manufacturer and approved by the Engineer. Deep tone accent colours shall be used and the unavailability of final coat colours may be the basis for rejecting materials for any one surface.

10.0 **SCHEDULE OF MEASUREMENT OF PAINT AREA:**

10.1 Irrespective of prime coats and number of paint coats applied to exposed painting surface area of column, walls, projections, ceilings, false ceilings and other surfaces (Except gates, doors windows and ventilators) shall be measured as per actual paint surface area for single time only and paid in accordance with quoted rate of Bill of Quantities.

11. **MEASUREMENT AND PAYMENT**

11.1 **General**

Except otherwise specified herein or elsewhere in Contract Documents, no measurement and payment will be made for the under mentioned specified works related to the relevant items of the Bill of Quantities. The cost thereof shall be deemed to have been included in the quoted unit rate of the respective items of Bill of Quantities.

The rates quoted by the Contractor in the Bill of Quantities shall include work to be executed under these specification in any floor and at any height except where otherwise specifically stated in the relevant item of Bill of Quantities and the Contractor shall not be entitled to any claim or claim any compensation on this account.

11.1.1 Preparatory works, including preparatory materials, scraping, scratching, sand blasting, cleaning, prime coating, priming, protection of finished works etc.

11.1.2 Polishing works, including preparatory materials, scraping, cleaning, sanding etc.

11.1.3 Before application of paint on existing surface the old paint surface shall be removed existing paint, filling of cracks, surface preparation and application of primer coat, if any.

11.2 **Painting / Acrylic based textured Coating**

11.2.1 Measurement

Measurement of acceptably completed respective type of painting works / Acrylic based textured coating (graffito) will be made on the basis of net actual length in square meter / square foot of the surface painted / coated as shown on the Drawings or as directed by the Engineer.

11.2.2 Payment

Payment will be made for acceptable measured quantity of respective type of painting / acrylic based textured coating (graffito) on the basis of unit rate per square meter / square foot quoted in the respective items of Bill of Quantities and shall constitute full compensation for all the works related to the item.

*** End of Section 6700 ***

ELECTRICAL WORKS

SECTION - 8001

GENERAL SPECIFICATIONS FOR ELECTRICAL WORKS

- 1.0 SCOPE OF WORK**
- 2.0 RULES & REGULATIONS**
- 3.0 AMBIENT CONDITIONS**
- 4.0 STANDARDS**
- 5.0 SYSTEM DATA**
- 6.0 EQUIPMENT**
- 7.0 DRAWINGS AND DATA TO BE FURNISHED BY THE CONTRACTOR**
- 8.0 MANUFACTURER'S INSTRUCTIONS**
- 9.0 GUARANTEE**
- 10.0 DANGER BOARDS WITH SIGNS, DESIGNATION AND SHOCK / FIRST AID CHARTS AND FIRE FIGHTING EQUIPMENT**
- 11.0 ASSOCIATED CIVIL WORKS**
- 12.0 INSTALLATION INSTRUCTIONS - GENERAL**
- 13.0 FACTORY TESTS**
- 14.0 TESTING - GENERAL**
- 15.0 APPENDICES TO BE FILLED IN BY THE BIDDER**
- 16.0 PAYMENT**

1.0 SCOPE OF WORK

The works related to the electrical system which is included in the Scope of this Contract as shown on the Drawings, stated in the Specifications and Bill of Quantities and explained in these Specifications. The works shall broadly include but not limited to the following:

- General Specifications for Electrical Works
- Low Voltage D.G. Set
- Indoor power Transformer
- H.T. Switchboards
- L.T Switchboards
- LT Distribution Boards
- Motor Control Centre
- Light Fixtures
- Low Tension Cables
- Wiring Accessories
- Conduits and Pipes
- Earthing
- Lightning Protection System
- Miscellaneous Items
- Structured Cabling Network
- Fire Alarm System
- Closed Circuit Television System
- Public Address System
- Cable Antenna TV System

The Contractor shall also be responsible to supply any other equipment not specifically mentioned in these Documents but which is necessary for proper operation of the works/system included in the scope of this Contract. The Contractor shall solely be responsible for ensuring proper functional requirements of different equipment. He shall also be responsible for furnishing any additional piece of equipment and for making modification in the equipment as desired and/or approved by the Engineer to achieve proper co-ordination with various equipment offered in the bid and also with those installed by others.

2.0 RULES & REGULATIONS

The entire electrical installation/work shall be carried out by licensed Contractor, authorised to undertake such work under the provisions of the Electricity Act 1910 and The Electricity Rules 1937 as adopted and modified upto date by the Government of Pakistan.

All works shall be carried out in accordance with the latest edition of the Regulations of the Electrical Equipment of Buildings issued by the Institute of Electrical Engineers-London, the Contract Documents, The Electricity Rules 1937 and bye-laws that are in force from time to time. Any discrepancy between these Specifications and any other rules and regulations shall be brought to the

notice of Engineer for his instructions and the discussion of the accepting/controlling shall be final and conclusive.

The Contractor shall be responsible for completing all formalities and submitting the test certificates as per prevailing rules and regulations, and shall have the installation passed by the Government Electric Inspector of that region. All requirements of the Electric Inspector and the WAPDA / MEPCO shall be complied with.

3.0 AMBIENT CONDITIONS

All material and equipment supplied and installed shall be designed, manufactured and tested to meet the following ambient conditions unless specifically stated otherwise for any material/ equipment.

Maximum indoors ambient temperature	:	45-Degree Celsius
Minimum indoors ambient temperature	:	Zero Degrees Celsius
Maximum outdoors-ambient temperature	:	50-Degree Celsius
Minimum outdoors-ambient temperature	:	Zero Degrees Celsius
Maximum Relative humidity	:	100 Percent
Maximum Altitude of project	:	220 meters above the mean sea level.

The atmospheric conditions are tropical and highly humid.

4.0 STANDARDS

The latest standards and codes of reputable organisations shall be applicable for the material and equipment specified herein and for installation work. Such organisations to be BSS, VDE, NFPA 99, NEC Article 517 etc. In case the Specifications laid down herein differ from those given in the standards, then the equivalent or better specifications shall govern. Wherever applicable the equipment shall also conform to the requirements of Pakistan Standard Institution (PSI).

Contractor shall maintain at the site office one copy of the standards / codes applicable to the works.

5.0 SYSTEM DATA

Unless otherwise specified elsewhere, all equipment and material shall be designed to operate satisfactorily with the following minimum requirements without any de-rating.

a) Voltage rating of equipment :	HT :	11 kV, 3 phase, +/- 10%
	LT :	400 V, 3 phase, +/- 10%
		230 V, 1 phase, +/- 10%

b) Frequency : 50Hz \pm 2Hz

In general, the electrical colour coding of switchgear cubicles, control panels, desks etc., shall be in accordance with the respective IEC Recommendations.

Live parts of electrical connections shall be colour coded according to IEC 446 as follows:

	Conductor Designation	Coding Alphanumeric	Colour
A.C. Network	Phase 1	L 1	red
	Phase 2	L 2	yellow
	Phase 3	L 3	blue
	Neutral	N	black
D.C. Network	Positive	L+	white
	Negative	L-	black
Earthing	Protective Earth	PE	green/yellow
	Earth	E	green/yellow

The colour coding for the secondary circuits of isolated power panel board is as follows:

Orange-Isolated Phase Conductor
Brown- Isolated Neutral Conductor
Green-Isolated Ground Conductor

Conductor insulation of secondary circuits of isolated power panel board shall be XLPE and PVC sheathed.

Control Cables

The Control Cables shall be manufactured according to specifications for L.T. Cables. The Control Cables shall be of multi-core, PVC insulated type withstanding without deterioration the conditions prevailing at the place of installation. The cross section of cable shall be as per the requirement of the system.

All the cores should be numbered and/or colour coded or otherwise properly identified. At-least 20% spare cores shall be provided in all Control Cables.

No separate payment is admissible for supplying, installing, testing and commissioning of control cables and is deemed to have been included in the BOQ rates of the respective equipment.

Distance in between power, communication and control cables shall be kept as per requirements laid down by NEC800, NFPA 70 and EN50174-2.

6.0 EQUIPMENT

6.1 IP Degree of Protection

The equipment shall have IP degree of protection as follows, unless mentioned other wise:

- IP 42 for indoor areas
- IP 54 for indoor damp areas
- IP 65 for outdoor areas

If properly rated equipment is not available, the Contractor shall provide field enclosures to attain the required IP degree of protection. If necessary cooling/exhaust fans and / or anti condensate heaters shall also be provided. No separate payment shall be made to attain the required IP degree of protection.

6.2 Identification & Labelling

All devices, meters, cabling, wiring and auxiliaries shall be properly labeled for identification. Labeling of equipment shall be done by means of flameproof material using indelible ink/markings. The labeling shall be such as to ensure uniformity and shall facilitate study of control diagrams/ drawings during operation and maintenance.

All labeling shall be of suitable size to be visible from the operating conditions/positions at site.

6.3 Lamp Test Facility

All equipment / switchboards, etc. shall be provided with common lamp test facility.

7.0 DRAWINGS AND DATA TO BE FURNISHED BY THE CONTRACTOR

The shop drawings, as-built drawings and/or technical data to be furnished by the Contractor for each electrical equipment, LT cable distribution layout & shall include, but not limited to the following:

- (a) Structural drawings showing foundations, RCC details dimensional plans,

elevation and sections on a suitable scale.

- (b) Electrical drawings showing:
- Line diagrams of Switchboards, Motor Control Centres, distribution boards and isolated power panels with detailed wiring diagrams, elevations/internal component layout and other standard details.
 - LT Cabling, Grounding/Earthing including all cable routing and support details.
 - Necessary execution details such as no. of cable/wires, size of conduits, cable routes, cable trays and cable trenches, etc.
 - Substation and Generator Room Equipment installation detail.
 - Manhole/Duct works.
- (c) Layouts of all LT cable routes with coordinates and levels.
- (d) Technical literature and manufacturer's characteristic data with the description of materials and weights of all equipment as instructed by the Engineer.

At least three (3) copies of the shop drawings and/or technical data of the equipment shall be submitted to the Engineer for checking and approval.

8.0 MANUFACTURER'S INSTRUCTIONS

The Contractor shall supply to the Engineer in properly bound form six (6) copies of manufacturer's instruction manuals for installation, testing, commissioning, operation and maintenance of the specified equipment including manuals of spare parts and tools of the equipment. At least two copies of the documents shall be submitted in original. The installation instructions shall be submitted 2 weeks prior to commencement of installation of each equipment, and operation and maintenance instruction at the time of commissioning. If the Contractor fails to provide the documents the Engineer shall withhold issuance of requisite certificates and deduct suitable amount from the payments to the Contractor.

9.0 GUARANTEE

The Contractor shall furnish written guarantee of the manufacturer or supplier with respect to satisfactory performance of each equipment. Guarantee shall be given for replacement and repair of part or whole of the equipment, which may be found defective in material or workmanship. The guarantee shall cover the duration of Maintenance Period as defined in the Conditions of Contract. This guarantee shall not relieve the Contractor of his obligations and he will be fully

responsible for the repair or replacement of any defective material in time, so as not to cause any undue delay in carrying out the repairs and/or replacements.

10.0 DANGER BOARDS WITH SIGNS, DESIGNATION AND SHOCK / FIRST AID CHARTS AND FIRE FIGHTING EQUIPMENT

Danger Boards having signs and designation of the room shall be installed on the external door of HT, LT, Power transformer, Low Voltage DG Set Rooms. Shock/First Aid Charts shall be installed in H.T, L.T and Low Voltage DG Set Rooms.

Potable fire fighting extinguisher suitable to control electrical fire shall be provided in H.T, L.T, Power Transformer and Low Voltage DG Set Rooms.

All the above items shall also be provided, wherever required to comply the requirements of the Pakistan Electricity Rules/Electric Inspector.

Laminated single line and adequate detail drawings on proper boards highlighting the main system features shall be displayed/ fixed in respective electrical and communication rooms.

11.0 ASSOCIATED CIVIL WORKS

Except where separately stated in the Bill of Quantities the cost of all civil works associated with any BOQ item of electrical works, such as excavation and back filling of earth, compaction of the earth, foundation pads, chiselling, making openings, etc. shall be included in the price quoted against respective items. No separate payment for such works will be made. Such works will also include repair of any damage to civil works caused by the Contractor during electrical installation.

12.0 INSTALLATION INSTRUCTIONS - GENERAL

The Contractor shall furnish all labour, materials, tools and equipment required to install, connect, test and commission all electrical equipment specified herein, whether or not such equipment is furnished by him or by others.

For all equipment to be installed by the Contractor, the Contractor shall supply and install all erection materials such as foundation bolts, washers, nuts, etc. as required and without any additional costs.

The Contractor shall set out the works himself as per Specifications and Drawings and shall properly position the equipment on specified foundation/location. In general, the manufacturer's instructions for installation shall be followed. Any defect or faulty operation of equipment due to the Contractor not following the manufacturer's instructions shall be corrected and repaired by the Contractor at his own cost.

For any deviation from the working drawings or specification that are deemed necessary by the Contractor due to site conditions, he shall submit the details and obtain the Engineer approval before starting such works.

13.0 FACTORY TESTS

All type and routine tests on Low Voltage D.G Set, Power Transformer, H.T Switchboards, LT Switchboards, Motor Control Centre, H.T Cables, LT Cables, and all other equipment shall be performed at the manufacturer's works in the presence of the Engineer or his Representative. Type tests may be waived off in case test certificates are submitted as certified by an Engineer approved standard laboratory of international repute; but merely producing the test type certificates will not relieve the manufacturer to carry out the required standard/routine tests.

The Contractor shall inform the Engineer about the date and time of test of each equipment at least two weeks in advance. This shall, however, be done after the Contractor has got the test procedures duly approved by the Engineer. The witnessing of test by the Engineer and the Employer shall not absolve the Contractor from his responsibility for the proper functioning of the equipment, and for furnishing the guarantees referred to in clause 9.0. All test results shall be supplied in quadruplicate. All expenses for carrying out the tests as incurred by the Engineer and the Employer to witness it shall be borne by the Contractor and deemed to have been included in the bid. Provision for at least two person's visit for Factory Acceptance Tests shall be made to include one representative each from the Employer and the Consultant/Engineer. The contractor shall undertake all formalities as may be required for the Engineer or his representative to enable him make the visit.

14.0 TESTING - GENERAL

14.1 Scope

Upon completion of the installation, the Contractor shall perform field tests on all equipment, materials and systems. All tests shall be conducted in the presence of the Engineer for the purpose of demonstrating equipment or system compliance with Specifications. The Contractor shall submit for Engineer's approval complete details of tests to be performed describing the procedure, test observations and expected results.

The Contractor shall furnish all tools, instruments, test equipment, materials, etc., and all qualified personnel required for the testing, setting and adjustment of all electrical equipment and material including putting the same into operation.

All tests shall be made with proper regard for the protection of the personnel and equipment and the Contractor shall be responsible for

adequate protection of all personnel and equipment during such tests. The cost of any damages or rectification work due to any accident during the tests shall be the sole responsibility of Contractor.

The Contractor shall record all test values of the tests made by him on all equipment. Four (4) copies of all test data and results certified by the Engineer shall be given to the Engineer for record purposes. These shall also include details of testing method, testing equipment, diagrams, etc.

The witnessing of any tests by the Engineer does not relieve the Contractor of his guarantees for materials, equipment and workmanship, or as any other obligations of Contract.

14.2 **Low Voltage D.G. Set**

Prior to the tests, the contractor shall submit manufacturer's recommended detailed description of the test procedures to be conducted for Engineer's approval.

The Contractor shall carry out full site load and no load tests in accordance with IEC, ISO or BS Specifications for site commissioning. The inspection and tests shall include but not be limited to:

Basic Tests:	Insulation Resistance Earth Continuity Earth Loop Impedance Polarity Phase Rotation Voltage and Frequency Starting System Protection Equipment
Battery:	Nominal Voltage Discharge Voltage Specific Gravity of Electrolyte Level of Electrolyte Charging System
Lubrication:	Check as required by manufacturer
Operational Check at Start-up	Oil Pressure Fuel Oil Leaks Operation of Safety Devices Operational Speed Automatic Control Instrument Check Exhaust Check Undue Vibration

Operational Check	Oil Pressure	
After one hour's run:	Oil Leaks	
	Cooling System	
	Oil Temperature	
Commissioning Test:	25% of full load	2 hrs.
	50% of full load	5 hrs.
	75% of full load	8 hrs.
	100% of full load	8 hrs.
	110% of full load	1 hr.

All commissioning and test results shall be recorded and compared with design data. A retest/commissioning shall take place if results are not satisfactory. All the tools, labour, POL, required for the testing and commissioning shall be provided by the Contractor at no extra cost. If required load is not available at site for testing the generators, the Contractor shall provide dummy load at site at no extra cost to the Employer. The correct functioning of the control equipment shall also be proved.

Battery Charger

Battery charger shall be static type and shall provide for both trickle and boost charging of the batteries when the engine is not in operation. The charger shall be of suitable capacity to fully recharge the completely discharged batteries within four hours at boost charge.

Control Panel

The Control Panel shall provide all the necessary control and monitoring devices of the Diesel Generating Sets. All the control and monitoring of the safety devices, alarms, protections, meters, lamps, etc. as mentioned in this Specifications and required as per good engineering practices for such an installation shall be provided in the Control Panel.

14.3 **Transformer Tests**

In addition to the insulation resistance test of the transformer, a polarity and phase rotation test shall also be made. Buchholz relay shall be tested for proper operation. Di-electric test shall be carried out on transformer oil prior to putting the same in operation.

14.4 **HT / LT Switchboards**

Each circuit breaker shall be operated electrically and mechanically. All interlocks and control circuits shall be checked for proper connections in accordance with the wiring diagrams given by the manufacturer.

The Contractor shall properly identify the phases of all switchgear and cables for connections to give proper phase sequence.

Trip circuits shall be checked for correct operation and rating of equipment served. The correct size and function of fuses, disconnect switches, number of interlocks, indicating lights, alarms and remote control devices shall be in accordance with approved manufacturer drawings. Nameplates shall be checked for proper designation of equipment served. Protective relays shall be tested and set at site prior to commissioning of the equipment.

14.5 **Insulation Resistance Test**

Insulation resistance test shall be made on all electrical equipment by using a meggar of 500 volts for circuits upto 250 volts and 1000 volt for circuits between 250 and 500 volts. For testing of 11 kV circuits, upto 5 kV meggar shall be used; the exact voltage shall be as advised by the equipment manufacturer unless otherwise advised by the Engineer.

The insulation resistance values of cables, transformer, switchgears, etc., shall be as per BSS, IEEE, NEC, ICEA and Pakistan Electricity Rules.

Before making connections at the ends of each cable run or joint between cables, the insulation resistance test of each cable section shall be made. H.T. cables shall be subjected to high voltage test as per recommendations of standard to which the cable is manufactured. Each conductor of a multi-core cable shall be tested individually with each of the other conductor of the group and also with earth. If insulation resistance test readings are found to be less than the specified minimum in any conductor, the entire cable shall be replaced and tests repeated on new cable. If cable joint is provided, then each cable section shall be tested, and joint made only after the tests have been made satisfactorily. Finally the completed cable length including the joints shall be tested.

The transformer and switchgears shall be given an insulation resistance measurement test after installation, but before any wiring is connected. Insulation tests shall be made between open contacts of circuit breakers, switches and between each phase and earth.

If the insulation resistance of the circuit under test is less than the specified value, the cause of the low reading shall be determined and removed. Corrective measures shall include dry-out procedure by means of heaters, if equipment is found to contain moisture. Where corrective measures are carried out, the insulation resistance readings shall be taken after the correction has been made and repeated twice at 12 hours interval. The maximum range for each reading in the three successive tests shall not exceed 20% of the average value. After all tests have been

made, the equipment shall be reconnected as required. Polarity test shall be made on single pole switching devices.

14.6 Earth Resistance Test

The Contractor shall make Earth resistance tests on the Earthing system, separating and reconnecting each earth connection.

If it is indicated that soil treatment or other corrective measures are required to lower the ground resistance values, the Engineer will determine the extent of such corrective measures.

The electrical resistance of the ECC together with the resistance of the Earthing leads measured from the connection with earth electrode to any other position in the complete installation shall not exceed one ohm.

Earth resistance test shall be performed as per Electrical Inspector's requirements. Where more than one earth electrodes are installed, the earth resistance test of each electrode shall be measured by means of resistance bridge instrument.

The complete lightning protection system shall be tested for continuity and earth resistance. The combined earth resistance at any point in the lightning protection system shall not exceed 10 ohms.

14.7 Completed Tests

After any equipment has been tested, checked for operation, etc., and is accepted by the Engineer the Contractor shall be responsible for the proper protection of that equipment so that subsequent testing of other equipment do not cause any damage to the already tested equipment.

14.8 Expenses

All expenses, i.e., travelling, boarding and lodging for carrying out the tests and witnessing by the Engineer shall be borne by the Contractor and are deemed to have been included in the BOQ rates of the respective equipment(s) by the Contractor.

14.9 Spare Parts

Contractor shall provide spare parts as identified in relevant appendix. The cost of each spare parts shall be carried over to relevant BOQ item and no extra payment shall be admissible in this regard.

14.10 Special Tools

Contractor shall provide special tools as indicated in Appendix-IV and as may be deemed essential for assembly, adjustment, dismantling, installation and maintenance reasons.

No separate payment shall be made for any special tools and cost shall be deemed to be included in the cost of the Contract.

15.0 APPENDICES TO BE FILLED IN BY THE BIDDER

The details regarding equipment manufacturers, deviations, etc., are to be furnished in the appendices attached with form of Bids, in accordance with the provisions of the clause "Requirements of Electrical Works" given in the instructions to Bidder, Volume - I.

16.0 PAYMENT

No separate payment shall be made for work involved within the scope of this section unless specifically stated in the Bill of Quantities or herein.

*** End of Section 8001 ***

SECTION - 8150

LIGHT FIXTURES

- 1.0 SCOPE OF WORK**
- 2.0 GENERAL**
- 3.0 APPLICABLE STANDARDS/CODES**
- 4.0 MATERIAL**
- 5.0 INSTALLATIONS**
- 6.0 MEASUREMENT AND PAYMENT**

1.0 SCOPE OF WORK

The work under this section consists of supplying, installing, testing and commissioning of all material and accessories of the complete Light fixtures as specified herein and/or shown on the Tender drawings and given in the Bill of Quantities.

The Contractor shall discuss the electrical layout with the Engineer and co-ordinate at Site with other services for exact locations and positions of the light fixtures.

The lighting fixtures with accessories shall also comply with the General Specifications for Electrical Works, Section-8001 and with other relevant provisions of the Tender Document.

2.0 GENERAL

The description of light fixtures is given in the bill of quantities, and stated on the drawings, and all relevant material is described in this Section. The determination of quality is based on certified photo-metric data covering the coefficient of utilisation, light distribution curves, construction material, shape, finish, operation, etc.

The Contractor shall submit at least two samples of each and every light fixture specified and obtain approval of the Engineer before purchasing. The quality and finishes of the local make light fixtures (if mentioned in BOQ) shall be same as that of standard manufacturer. The accessories such as ballast, LED drivers, lamps, ignitors, etc., for all type of light fixtures shall be of make as stated in list of approved manufacturers. Approved equivalent against those specified will be accepted if the specified one is/will not be available. For any substitution the Engineer's approval is necessary.

All fixtures shall be finished in standard colour schemes as mentioned in the manufacturer's catalogue for respective fixtures, unless specifically stated in the Specifications, Drawings or Bill of Quantities or directed by the Engineer.

3.0 APPLICABLE STANDARDS/CODES

The latest editions of the following standards/codes shall be applicable to the material specified within the scope of this section:

IEC 60598-2-1-	Particular requirement- Fixed general purpose luminaire
IEC 60598-2-2-	Electrical Insulation Class I
IEC 62471 -	Photo biological Safety of lamps and lamps system
IEC 62031 -	LED modules for general lighting – Safety specifications

IESNA LM80	-	Testing report for LED Chips with TM21 extrapolation graph
IEC 61048 & 61049	-	Capacitors for use in TL, HP mercury and LP sodium vapour discharge lamp circuits.
IEC 60598 & BS EN 60598	-	Luminaires
BS 2560	-	Exit Signs
ISO 7010	-	Signs for the purposes of accident prevention, Fire protection, health hazard information and Emergency evacuation.

4.0 MATERIAL

4.1 LED Essential/Waterproof Batten Light Fixture:

The Contractor shall furnish and install the complete LED Batten luminaires replacement for complete single conventional 1x18W TL-D/1x36W TL-D & double 2x36W TL-D fluorescent batten. The batten light fixtures shall be of proper rating as shown on the drawings. The LED batten light fixture shall be 1200mm long for 36/28watts and 600mm long for 14watts respectively as specified.

The luminaire shall be cool white, with colour rendering and light colour of 840 characteristics. The luminaire shall have such distribution to achieve general lighting application parameters. The luminaire shall use high efficiency diffuser to achieve at least 50% energy savings compared to conventional fluorescent and waterproof light fixture. The luminaire shall offer a composite system efficiency of at least 90 Lumen/Watt for Essential LED batten and at least 100 Lumen/Watt for Waterproof LED batten having an average lumen package of up to:

3800 lumens ($\pm 5\%$) in 36W replacement for 2x36W waterproof TL-D Batten

2700 lumens ($\pm 5\%$) in 28W replacement for 2x36W fluorescent TL-D Batten

1350 lumens ($\pm 5\%$) in 14W replacement for 1x36W fluorescent TL-D Batten

The LED luminaire shall be designed for lumen maintenance of L70 or 70% at the end of useful life at ambient temperature of 25 deg. C. The complete luminaire shall have a useful life of 40,000 burning hours. The luminaire shall be suitable for ambient temperature range of between -20 to +40 degrees Celsius. Third party IEC 60598 Test Report shall be measured/corrected for $T_a = 25$ degrees Celsius. The luminaire including the driver will include a warranty of at least 3 years against

manufacturing defects.

The housing of Essential LED Batten light fixture will include integrated heat sink and optical system. The housing will be made of galvanized sheet having white Powder coated & suitable for indoor & semi-indoor environment. The optical cover made up of Polycarbonate with UV Protected Shielding cover. The fixing mechanism will be through clip made of Stainless steel. Appropriate size bushed wire entry holes, fixing holes, and earth terminal shall be provided. The driver shall be integrated within the luminaire.

The housing of Waterproof LED Batten light fixture will be made of Polycarbonate & extrusion process & suitable for outdoor environment. The optical cover made up of Polycarbonate with UV Protected Shielding cover. The product shall be protected against harsh industry environments IP65 rating for dust & water protection. The luminaire shall have no harmful effect against water projected from any direction. The luminaire shall have impact protection classified as IK07 operating temperature. The driver shall be integrated with the luminaire in a separate gear compartment with similar Index protection.

The internal wiring of LED batten light fixtures shall be done with heat resistant wires at the manufacturer's factory. The internal wiring shall be clipped properly and heat resistant sleeves be provided on cables passing near driver. Connectors suitable for connecting 2.5 sq.mm cable conductors shall be provided for supply connections. An earth terminal for connection to 2.5-sq.mm cable conductor shall be provided.

The light fixtures shall be furnished with Perspex diffusing panels "040 opal acrylic" (minimum sheet thickness 3mm) etc. as specified on the drawings or in BOQ. The luminaire shall have provision of both surface, Suspended mounting with dimension compatible to conventional florescent fixture. Mounting Clips for installation must be available.

IP degree of Protection shall comply with the requirements laid down in Section 8001. Standard luminaries with manufacturer's recommended modifications, such as additional gasket, etc., shall be provided to attain required protection level.

4.2 LED Smart Panel Light Fixture:

The Contractor shall furnish and install the complete LED Panel luminaires as replacement for complete double conventional 2x36W TL-D fluorescent light fixture. The Smart Panel shall be of proper rating as shown on the drawings. The LED Panel shall have dimensions of 297 x 1197 x 75mm/595 x 595 x 75mm for 36 watts respectively as specified.

The luminaire shall be cool white, with colour rendering and light colour of

840 characteristics. The LED shall have a colour consistency preferably within 5 SDCM (standard deviation of colour matching) as defined by McAdam. The colour temperature variation should be restricted as per ANSI C78.377A with CCT variation limiting within 500K for nominal CCT of 4000K / 6500K.

The luminaire shall offer a composite system efficiency of at least 110 Lumen/Watt and a lumen package of up to 3,800 lumens ($\pm 5\%$) in 36W replacement for 2x36W conventional TL-D fluorescent fixture. The luminaire shall use high efficiency diffuser and reflector to achieve at least 50% energy savings compared to conventional fluorescent light fixture.

The system should be designed for fully hospital and office lighting & possess higher uniformity to have a smooth white light of high colour consistency & high system efficiency. For the better UGR control one, the luminaire optics should fully comply with hospital lighting norms with UGR value (Unified Glare Rating) < 25 . The beam angle of the optic should be around 140° .

The LED luminaire shall be designed for lumen maintenance of L70 or 70% at the end of useful life at ambient temperature of 25 deg. C. The complete luminaire shall have a useful life of 50,000 burning hours. The luminaire shall be suitable for ambient temperature range of between -20 to +40 degrees Celsius. Third party IEC60598 Test Report shall be measured/corrected for $T_a = 25$ degrees Celsius. The luminaire including the driver will include a warranty of at least 3 years against manufacturing defects.

The housing will include integrated heat sink and optical system. The housing will be made of electrogalvanized cold rolled steel sheet, pre-treated, painted and stove enamelled in white colour & the fixture will be provided with a plastic cover that is aesthetical for the hospital environment. The heat sink will design in such way to create better air-flow for better heat transfer. The light cover is made up of PMMA optics lens with PS diffuser & a suitable reflector for the best uniformity. Appropriate size bushed wire entry holes, fixing holes, and earth terminal shall be provided. The driver shall be integrated within the luminaire.

The internal wiring of LED batten light fixtures shall be done with heat resistant wires at the manufacturer's factory. The internal wiring shall be clipped properly and heat resistant sleeves be provided on cables passing near driver. Connectors suitable for connecting 2.5 sq.mm cable conductors shall be provided for supply connections. An earth terminal for connection to 2.5-sq.mm cable conductor shall be provided.

The luminaire shall have provision of recessed, surface or suspended mounting etc. as specified on the drawings or in BOQ with dimension

compatible to conventional florescent fixture. Mounting Clips for installation must be available. Shop drawings shall be submitted by contractor for approval of Engineer.

4.3 LED Down Light Fixtures

The Contractor shall furnish and install the surface mounted LED Downlight luminaires as replacement for single 1x18W or double conventional 2x18W PL-C incandescent/ compact fluorescent light fixture. The LED downlights shall be of proper rating as shown on the drawings. The LED Downlights shall have dimensions of 122/167/218mm dia. for 7/11.5/16 watts respectively as specified.

The luminaire shall be cool white, with colour rendering index greater than 80 and light colour of 840 characteristics. The Downlighter must be provided with a polycarbonate diffuser having high haze and light transmission for uniform light output. The beam angle must be in the ranges in between 95 to 100 degrees for better illumination.

The LED downlights shall have minimum system efficacy of at least 95 lm/W with 55% energy-saving as compared with conventional compact fluorescent lamp downlight fixtures and shall have a useful life of 50,000 burning hours for 70% lumen maintenance at the end of useful life at ambient temperature of 25 deg. C.

The downlighter shall have high reflectance white painted polycarbonate front element or High purity aluminium with high reflectance coated reflector along with tempered glass on the front cover. The housing will include integrated heat sink and optical system. The heat sink made with Die Cast Aluminum should be design in such way to create better air-flow for better heat transfer as furnished by the manufacturer or as specified in the drawings or BOQ. The fixing mechanism of recessed down light will be through spring fasteners.

Where surface mounted downlights are used, the housing will be made of Plastic and enclosed in white powder coated die-cast aluminium body for surface mounting installation. The body shall have fins as heat sink.

The types of fixtures with manufacturer's catalogue reference are given on the fixture schedule and in bill of quantities. Equivalent fixture may be acceptable provided that the contractor submits for review all necessary data indicating photometric curves to show that the fixture proposed are of the same type, construction and quality.

4.4 Compact Fluorescent Light Fixtures

The compact fluorescent light fixtures shall be as stated on drawings and bill of quantities. The light fixture shall be finished in standard colours

unless otherwise stated on drawings or directed by Engineer. All compact fluorescent light fixtures shall be of international standard and quality.

The lamps for compact fluorescent light fixtures shall be CFL type with normal or electronic control gear and shall be supplied and installed according to the wattage/type as indicated on drawings.

Weatherproof bulkhead incandescent/compact fluorescent light fixture shall comprise of plastic body and gasketed clear glass cover secured to the body by means of wing nuts/screws to give a weatherproof and watertight fit. The gasket shall be weather resistance type. The lamp holder shall be of bi-pin brass having porcelain outer ring or 2/4-pin base for compact fluorescent lamps with normal control gear as per requirements.

The glass shade of the light fixtures shall be opal white or clear as furnished by the manufacturer with the light fixture unless specified and free from any air bubbles or voids. The shade may be spherical, cylindrical, flattened bottom or any other shape as specified in the drawings or BOQ.

4.5 Exit Sign – Emergency Light Fixture

The exit sign emergency light fixture shall be maintained type with self contained, polycarbonate body, Gear Type and sealed nickel metal hydride batteries providing a backup of atleast 3 hours if not mentioned otherwise elsewhere. The light fixture shall have steel body powder coated in perma white finish, complete with screen printed acrylic legend panel. 2 X High Power 1W LED lamp and give 20 m route space. Legend panel shall be bottom entry for case of installation near walls. The legend pictogram shall be green colour and as approved by the Engineer.

4.6 LED Flood Light Fixture

The Contractor shall furnish and install the complete Boundary Wall luminaires maintaining avg. 30 lux for existing outdoor mixed traffic area, fully IP 66 with corrosion resistant die cast aluminum housing, silicon gas kit, thermally hardened glass complete with LED drivers, surge protection and all accessories/ components required for the proper operation of the system. The luminaries shall be fully flexible for future upgrades and easy replacements for maintenance purposes.

The luminaire shall have such distribution to achieve flood lighting application parameters. The luminaire shall offer a composite system efficiency of at least 100 Lumen/Watt and a lumen package of up to 13,000 for 120W+/-5W. The light fixture have three different optical beam angles Symmetric Wide Beam & Asymmetric Medium Beam & Narrow Beam optics according to application.

The LED light fixture should be designed for lumen maintenance of L70 or 70% at the end of useful life at ambient temperature of 45 °C and shall be capable to operate efficiently within the temperature limit of -40 °C to 50 °C. The complete light fixture should have useful life of 50,000 burning hours.

4.7 High Pressure Sodium Lamp

The high-pressure sodium SON-T plus lamp shall be of increased output tubular of rating 70 Watt and 400 watt as shown on the drawings. The base of the lamp shall be E40 with 6600 and 55,000 lumens output for 70 Watt and 400 Watt lamps respectively. The colour-rendering index Ra shall be 23. These lamps shall comply with EN60662.

4.8 Ballast for High Pressure Sodium Lamps

The ballast for high pressure Sodium lamps shall be polyester resin filled, totally encapsulated electromagnetic of copper / iron construction with leak proof body for use in combination with an external ignitor. The ballast shall fully comply with international Standards on Safety and performance, design compliance to IEC 60922/60923. The ballast shall be suitable for application in luminaries or poles under normal humid conditions. The ballast shall conform to the characteristics and wattage of the lamps. The wattage of lamp and ballast and a wiring diagram and other relevant data shall be printed on the body of the ballast. The power loss of the ballast shall not be more than 13.5-Watts for 70-Watts lamp and 28-Watts for 400-Watts lamp. The ballast shall be provided with insulated block of terminals for connecting up to 6 sq.mm cable with separate earth terminal.

4.9 Electronic Ignitors for High Pressure Sodium Lamps

The electronic ignitors for high-pressure sodium lamps shall be compact and light in weight with reliable and smooth starting behaviour. The ignitors shall be suitable for specified wattage of high-pressure sodium lamps and other requirements. The ignitors shall fully comply with IEC 60662 and EN 60926 regulations. The ignitors shall be provided with screw terminal / blocks and simple stud or screw mounting arrangement.

4.10 Capacitors for High Pressure Sodium Lamps

The capacitors for use in combination with high-pressure sodium lamp circuits shall be high-quality electrolytic capacitors for correction of power factor. The capacitors shall be of appropriate rating and type for the relevant lamp wattage. All capacitors shall be fitted with an internal discharge resistor, have a fuse fitted and be of self-healing type. Capacitor shall conform to IEC 61048/61049.

4.11 Flood Light Lanterns

The flood light lanterns shall have lamps of ratings specified in BOQ/ Drawings and shall be fully equipped with high grade reflector, corrosion proof housing with integral gear box, (Double insulation Class-II), compensated electrical control gear etc. complete with all internal wiring.

The flood light lanterns shall have non-corrosive, injection moulded, heat and UV-stabilized body, hammered aluminium reflector brightened and anodised, thermally – hardened 5 mm minimum glass, stainless steel snap-on hinged-clips, stainless steel protractor, hot dipped galvanized steel mounting brackets and stainless steel fixing accessories.

The housing shall be dust proof and jet proof to IP66, such that no internal cleaning shall be required.

4.12 LED Street Light Fixture

The road light fixture shall be an attractive modern appearance, high performance lantern suitable for 90W or 200W LED lamp as given in the BOQ/drawing.

Light fixture shall be provided with solid die cast aluminium housing, heat resistant silicon rubber gasket in optical LED compartment, DME type optic, tampered glass cover and shall be coated with powder of colour RAL 7040 ensuring no discoloration when exposed to UV light.

The light fixture shall be designed to receive power either from the battery or from the AC source. The light fixture shall have the following characteristics:

Voltage	=	220-240 VAC
Surge Protector	=	10 kV
Power Factor	>	0.9 (nominal power)

The light fixture shall have IP 66 protection to ensure long reliable performance and minimize maintenance requirement and an Impact resistance of IK 08 with insulation Class I. Use of chemical glue shall NOT be allowed to avoid probable breakdown of water-proof and dust-proof seal.

The light fixture should have a minimum color rendering index (Ra) of 70 + 5 and a color temperature of 4000K for maximum efficacy with an average output of at least 10,000 lumens for 90 Watt and 22,000 lumens for 200 Watt LED Fixture. The LED should have a color consistency within 5 SDCM (Standard Deviation of Color Matching). The color temperature variation of the LEDs should be restricted as per ANSI

C78.377A with CCT variation limiting within 500K for nominal CCT of 4000K.

The LED light fixture should be designed for lumen maintenance of L70 or 70% at the end of useful life at ambient temperature of 45 °C and shall be capable to operate efficiently within the temperature limit of -40 °C to 55 °C. The complete light fixture should have useful life of 50,000 burning hours.

The light fixture shall be fully compatible with future LED upgrades when they become available. It shall have a modular design to upgrade / replace with new LED modules or LED drivers at site conveniently with minimum effort. All electronic components/drivers shall be mounted on a separate removable gear tray. Light fixture housing shall have a tool less access by opening the cover.

The proposed LED road lighting light fixture shall be provided with in-built surge protection system to protect the electronic driver and LED system. Minimum surge protection rating is 10kV.

The housing shell, under the circuit board, shall be specially designed to ensure perfect contact between the circuit board and the light fixture housing for efficient heat dissipation. Only Metal Core PCBs shall be used to maximize heat transfer process and to offer reinforced electrical insulation via di-electric layer. The Metal Core PCB should be mounted on the housing using a highly efficient thermal interface material.

The optical LED compartment shall have a thermally hardened glass cover and high quality silicon gasket. The Glass cover will be tightly secured with the housing. The light fixture should have flexible optical system to achieve lighting parameters for required class of roads. The light fixture should offer a composite system efficiency of at least 100 lumen/Watt.

Specially designed lens system with unique inner and outer profile for high efficiency LED shall be provided to ensure maximum spacing between the poles and cover higher road widths. Multi layer optics design to ensure adequate luminance and luminance uniformity in the unlikely event of individual LED failure. The light fixture should offer choice of narrow, medium and wide beam light distribution.

The lamp position shall be adjustable to at least three positions to facilitate the changing of photometric distributions.. The photometric data of the lantern shall be authenticated by an Internationally Accredited Lighting Organisation.

Luminance level calculation with average luminance of the road surface, overall uniformity of road luminance, threshold increment, longitudinal

uniformity of road surface luminance and surround ratio achieved shall be submitted by the Contractor / manufacturer for verifying conformance to international lighting standards and approval of the Engineer.

4.13 LED Chips and Driver

The LED chip shall be from Cree / Nichia / Lumileds make or approved equivalent. The LED driver shall be designed to operate large array of high power LED's through current controlled output. The driver shall be suitable for operate up to 250VAC 50/60Hz mains supply. The LED driver shall have an efficiency of at least 90%. Fixed Output LED Driver (PSU) shall be integrated within each LED luminaire. The Driver compartment cavity and gear tray shall be designed with tool-less access for maintenance and replacement.

The light fixtures including the driver will include a warranty of at least 3 years against manufacturing defects. The cost of such provision will deemed to have been respective BOQ item of light fixture and no separate payment shall be admissible in this regard.

The LED driver shall fully conform to following specifications:-

- 1) BS-EN 61347-1 - General and safety requirements.
- 2) BS-EN 61347-2-13 - Particular requirements for DC or AC supplied electronic control gear for LED modules.
- 3) BS EN 55015: 2013 – Emission – Electrical lighting and similar equipment
- 4) BS EN 61547: 2009 – Immunity – Equipment for general lighting purpose
- 5) BS EN 61000-3-2: 2009 – Limits for harmonic currents emissions.
- 6) BS EN 61000-3-3: 2008 – Limits for voltage fluctuation and flicker.
- 7) BS EN 62493 – Assessment of lighting equipment related to human exposure to electromagnetic fields

5.0 INSTALLATION

5.1 General

The mounting heights of light fixtures are indicated on the drawings, and positions of fixtures are according to the mentioned scale.

The Contractor must ensure that the light fixtures are installed uniformly with respect to the dimensions of the area. Any modifications due to site conditions may be made with the approval of Engineer. All fixtures shall be carefully aligned before fixing in position.

The wiring between ceiling rose or terminal box and the fixture shall be carried out with 3-core 1.0 sq.mm and 1.5-sq.mm flexible copper

conductor PVC/PVC cable respectively for circuits protected by 10 amps and 15/20 amps MCBs. The wiring inside light fixture body shall be done with heat resistant cables or PVC insulated cable in heat resistant sleeves as approved by the Engineer.

Glasses, shades, reflectors, diffusers, etc., must be in a clear condition after installation. All light fixtures shall be earthed by an earth wire connected to the earth terminal in the fixture.

5.2 Street Light / Flood Light Fixture

The proposed street light fixture / flood light fixture shall be installed on the light pole/mast as per manufacturer's installation instructions. The road light fixture shall be properly levelled and the lamp adjusted to the appropriate position and all screws, bolts checked for tightness, etc. The light fixture shall be connected to the supply and earth at the proper terminals in the fixture.

5.3 Flood Light Lanterns

The flood light lanterns shall be installed on truss/G.I. bracket as per details shown on the drawing. Manufacturer's installation instructions shall be followed. The G.I. bracket shall be installed on column as shown on drawing. The exact location, rating and tilt/pan angles of light fixtures shall be finalized at site to suit the flood lighting requirements. Engineer's decision will be binding and final.

5.4 LED Batten / Panel Light Fixture:

LED Batten or Panel light fixtures on the surface of ceiling shall be installed with the back of the body flush with the ceiling surface, and in a manner so as to facilitate wiring. Nylon plugs and galvanized steel bolts or screws shall be used for fixing the light fixture to the ceiling. For light fixtures installation on false ceiling the installation method/detail shall be coordinated with ceiling design and submitted for approval of Engineer. Care shall be taken to prevent the weight of the fixture from being transferred to the false ceiling.

Pendant light fixtures shall have two holes in the top of each casing for supporting to the ceiling by a 3/4" dia. galvanized pipe or any other standard method as approved by the Engineer. Wiring from ceiling rose to the fixture shall be done through the pipe. Proper arrangements such as long threads with check nuts, etc. for minor adjustment in the mounting heights of the fixtures shall also be provided.

5.5 LED Down Light Fixture

LED downlight fixtures shall be installed on the surface of ceiling or wall by means of nylon plugs and galvanized steel screws, such that their

back finish flush with the surface for exposed conduits and flush with outlet box for concealed conduit system. Wherever convenient, screws for fixing light fixtures shall be screwed into the holes of the outlet box. The lights on false ceiling shall be installed in a manner as described for LED Panel light fixture.

6.0 MEASUREMENT AND PAYMENT

6.1 General

The Contractor's bid amount against each Bill of Quantities item as given below shall include supply, installation, testing, commissioning and completion for all work specified herein and/or shown on the Bidding Drawings related to the item.

6.2 LED Batten / LED Smart Panel / LED Downlight / LED Exit Light / CFL Bulkhead / LED or Conventional Flood Light/ LED Street Light Fixture

The Contractor's bid amount against each Bill of Quantities item as given below shall include supply, installation, testing, commissioning and completion for all work specified herein and/or shown on the Bidding Drawings related to the item.

6.2.1 Measurement

Measurement shall be made for each type of light fixture including all accessories acceptably supplied and installed by the Contractor as complete unit.

6.2.2 Payment

Payment shall be made for the number of units measured as provided above at the contract unit price each and constitute full compensation for supplying, installing, connecting, testing and completion of LED Battens / LED Smart Panel / LED Downlight / LED Exit Sign / compact fluorescent Bulkhead including all accessories such as capacitors , LED drivers, LED Chips, LED optics, connecting cables & connectors, suspension rods and pendent arrangement, GI pipe bracket, ceiling supports, internal wiring, nuts, bolts, screws, etc., as required and complete in all respects.

6.3 High Pressure Sodium Flood Light/ LED Flood Light / LED Street Light Fixture

The Contractor's bid amount against each Bill of Quantities item as given below shall include supply, installation, testing, commissioning and completion for all work specified herein and/or

shown on the Bidding Drawings related to the item.

6.3.1 Measurement

Measurement shall be made for each type of light fixture including all accessories acceptably supplied and installed by the Contractor as complete unit.

6.3.2 Payment

Payment shall be made for the number of units measured as provided above at the contract unit price each and constitute full compensation for supplying, installing, connecting, testing and completion of High Pressure Sodium Flood Light / LED Flood Light Fixtures/ LED Street lights including all accessories such as ballasts, capacitors, igniters, LED drivers, nuts, bolts, screws, etc., including PVC pipe, foundation etc., as required and complete in all respects.

*** End of Section 8150***

SECTION - 8220

WIRING ACCESSORIES

- 1.0 SCOPE OF WORK**
- 2.0 GENERAL**
- 3.0 APPLICABLE STANDARDS/CODES**
- 4.0 MATERIAL**
- 5.0 INSTALLATIONS**
- 6.0 MEASUREMENT AND PAYMENT**

1.0 SCOPE OF WORK

The work under this Section consists of supplying, installing, and commissioning of all material and services of the complete Wiring Accessories including switches, switch sockets, etc., as specified herein and/or shown on the Bidding drawings and stated in the Bill of Quantities.

The Contractor shall discuss the electrical layout with the Engineer and coordinate at Site with other services for exact location and position of all wiring accessories.

The wiring accessories such as switches, switch socket outlets, socket outlets and ceiling roses, etc. shall also comply with the General Specifications for Electrical Works Section 8001 and with other relevant provisions of the Bidding Documents.

2.0 GENERAL

The locations of the wiring accessories such as switches, sockets, etc. are tentatively shown on the drawings. The Contractor shall ensure the exact positions and locations of wiring accessories in coordination with other services drawings, as per site requirements and as directed by the Engineer. The Contractor shall be responsible for proper functioning of wiring accessories after installation and commissioning.

The description of switches, switch sockets, socket outlets etc. are given in the Bill of Quantities, stated as drawings and in this section. The Contractor shall submit sample of each and every item of wiring accessories for the approval of the Engineer.

3.0 APPLICABLE STANDARDS/CODES

The latest edition of following standards & codes shall be applicable for the materials specified within the scope of this section :

- | | | |
|---------|---|---------------------------------------------------------------------------------|
| BS 3676 | - | Switches for domestic and similar purposes. |
| BS 4343 | - | Industrial plugs, socket outlets and couplers for AC and DC supplies. |
| BS 2135 | - | Capacitors for radio interference suppression. |
| BS 67 | - | Ceiling roses. |
| BS 546 | - | 2-pole and earthing pin plugs, socket outlets and socket outlet adaptors. |
| BS 1362 | - | Specification for general purpose fuse links for domestic and similar purposes. |

- BS 1363
(Part 4-1995) - Specification for 13A fused connection units: switched and unswitched.
- BS 5733
(1995) - Specification for general requirements for electrical accessories.
- DIN EN
60669-1 - Switches for household and similar fixed electrical installations.

4.0 MATERIAL

4.1 Switches/Blank Face Plates

Switches for controlling light and fan points shall be single pole, rated for 10 Amps, 250 volts AC. The body of the switches shall be of thermoplastic with faceplate suitable for flush mounting and colour as approved by the Engineer. The switches shall be gang type having silver tipped contacts and shall operate with snap action.

Unless otherwise specified wherever switches control only the light points, these shall be plate type gang switches installed on common outlet boxes. Where only sheet steel back box is indicated on drawings, blank face plates shall be provided of same make and model as that of switches.

Where specified weather proof or metal front plates shall be used with single grid type switches. The plate shall be finished in specified colour or as otherwise directed by the Engineer.

The bell push switches shall be spring loaded type with the identification symbol embossed on it.

Two-way and intermediate switches shall be used to control lights from two or more different locations particularly in staircase as shown on the drawings.

4.2 13A Switch-Socket/Socket Outlets

Switch socket/Socket units shall be 3 pin, 13 A 250V, AC with faceplate of colour as approved by Engineer. The outlets shall be heavy-duty type suitable for mounting on sheet steel outlet box. The 13 Amps Switch socket/Socket outlets shall have sheltered live contacts and designed such that the earth pin of plug is engaged to socket earth before making of live contacts.

Where metal plate switches are installed, the switch socket units shall also be provided with front plate of similar design.

4.3 15A Socket Outlets

15 Amps Socket Outlets shall be 2 pin + earth, 250V AC socket outlets with faceplate of colour as approved by the Engineer by the Engineer.

The outlets shall be heavy-duty type suitable for mounting on sheet steel outlet box. The 15 Amps Socket Outlets shall be designed such that the earth pin of plug is engaged to socket earth prior to making contact to the live contacts.

4.4 32A Industrial Socket Outlet

The 32A, industrial socket outlet shall be weather proof conforming to the standard and requirements of relevant IEC codes.

The socket outlets shall be of heavy-duty type suitable for outdoor installation. The socket outlet shall be mounted on polycarbonate enclosure and have gasketed cover and window, captive cover screw type. All socket outlets shall be supplied with matching plugs.

4.5 64A Industrial Socket Outlet

The 16A, industrial socket outlet shall be weather proof conforming to the standard and requirements of relevant IEC codes.

The socket outlets shall be of heavy-duty type suitable for outdoor installation. The socket outlet shall be mounted on polycarbonate enclosure and have gasketed cover and window, captive cover screw type. All socket outlets shall be supplied with matching plugs.

4.6 Connection Unit

Connection Unit shall be used to supply to appliances where so specified or shown on drawings. (Air conditioner/Hand drier / Water heaters etc.).

It shall be rated for 20A, 250V AC or as shown on drawings/BOQ. The body shall be of thermoplastic material. Installation shall be surface/ concealed as required.

Face plate and colour to be as per approval of Engineer.

Connectors shall be of best quality (for Phase, Neutral and Earth) and suitable for the size of wiring.

The connection unit shall have the following features as per requirement in B.O.Q or as shown on drawing.

- 20 A Double Pole Switch
- Fuse – Rating as per requirement of appliance
- Neon Indication light
- Grommetted outlet on face plate suitable for flexible wiring connection to appliance

4.7 Ground Jack Module

Ground jack modules are used to make convenient ground connections for medical equipment of operation theaters. These unit contain ground jack receptacles and a ground bus. These modules shall be furnished with type #304 brushed stainless trim. These modules shall be provided with 30A twist-to-lock ground jacks, 1 No. copper ground bus bar 1/8" thick x 3/4" wide and lug suitable for 2.5 sq. mm. earth cable connection.

4.8 Fan Dimmers

The fan regulator/dimmer shall be made of low voltage electronic components with essential radio frequency compressor and shall be designed for smooth speed control/variation of fans. The regulators/dimmer and fan control switches shall be of same make and colour as that of the approved wiring accessories. The regulator/dimmer and fan-controlling switch shall preferably be mounted on same face plate. They shall be suitable for flush mounting on a sheet steel outlet back box.

4.9 Sheet Steel Back Boxes

The sheet steel boxes for installation of switches, fan dimmers, socket, outlets and blank face plates shall be made of 16 SWG sheet steel having appropriate dimensions. The box shall have suitable arrangement for receiving the conduit(s). An earth terminal shall be provided for connecting at least three earth wires of 4-sq.mm size. The outlet box shall be finished in powder-coated paint. The sheet steel back box shall be as approved by the Engineer.

4.10 Ceiling Roses

The ceiling roses shall be suitable for 5 amps 250 volts single-phase ac. It shall have white plastic moulded base plate and copper or brass terminals suitable for connecting at least two wires of 2.5 sq. mm size. The ceiling rose shall have a cover with cable inlet hole suitable for multicore PVC insulated and PVC sheathed cable.

5.0 INSTALLATION

5.1 General

The mounting heights of all wiring accessories are stated on the drawings. In case the mounting height is not mentioned, the instructions of the Engineer shall be obtained before fixing.

5.2 Wiring Accessories Installation

All wiring accessories such as Switches, Blank Face Plates, 13/15A Switch Socket, 32/64/125A Industrial Socket Outlet, Connection Units & ground jack modules shall be installed on 1.63 mm (16 SWG) thick sheet steel box recessed in wall/column/floor. The faceplate shall be fixed on sheet steel box by means of flat head galvanized or brass screws sunk in the faceplate so as to finish flush with the surface. Matching screw caps shall be installed on the opening for screw in faceplates.

The units installed in integrated bed head units shall be fitted with the parallel power tracks provided with the unit.

6.0 MEASUREMENT AND PAYMENT

6.1 General

The Contractor's bid amount against each Bill of Quantities item as given below shall include supply, installation, testing, commissioning and completion for all work specified herein and/or as shown on the Bidding Drawing related to the item.

6.2 13A Switch Socket/Socket Outlets, 15 Amps Switch Socket/Socket Outlets, 32/64/125A Industrial Socket Outlet Connection Units & Ground Jack Module

6.2.1 Measurement:

Measurement shall be made for the total number of each type of socket outlet complete with sheet steel back boxes, polycarbonate enclosure and all accessories acceptably supplied and installed by the Contractor as a complete unit.

6.2.2 Payment:

Payment shall be made for the total number of units measured, as provided above, at the Contract unit price each and shall constitute full compensation for supplying, installing, connecting,

testing and completion of each type and rating of outlet including screws, screw caps, sheet steel box, polycarbonate enclosure, nuts, bolts and other accessories as required.

*** End of Section 8220***

SECTION - 8230
CONDUITS AND PIPES

- 1.0 SCOPE**
- 2.0 GENERAL**
- 3.0 APPLICABLE STANDARD/CODES**
- 4.0 MATERIAL**
- 5.0 INSTALLATION**
- 6.0 MEASUREMENT AND PAYMENT**

SECTION - 8230

CONDUITS AND PIPES

1.0 SCOPE

The work under this section consists of supplying, installing and commissioning of all material and services of the complete Conduits and Pipes as specified herein and/or shown on Tender Drawings and stated in the Bill of Quantities.

The Contractor shall discuss the electrical layout with the Engineer and co-ordinate at Site with other services for exact route, location and position of the conduits and pipes.

The conduits and pipes with accessories shall also comply with the General Specifications for Electrical Works, Section-8001 and with other relevant provisions of the Tender Document.

2.0 GENERAL

The extent of works shown on the drawing does not indicate the exact position of conduits and pipes. The Contractor shall ensure exact location and route of conduit and pipes in coordination with other services drawings, as per site requirements and as directed by the Engineer.

The conduit system shall be continuous with manufacturer's recommended accessories.

The quality and material for the accessories of conduits and pipes such as sockets, end cap, elbows, bushings, bends, inspection/pull boxes, round boxes, etc., necessary for the complete installation shall be similar to that of conduits or pipes. All the accessories shall be supplied by the Contractor without any extra cost and deemed to have been included in the price of conduits/pipes.

Pull wire shall be laid in all empty conduits.

3.0 APPLICABLE STANDARD/CODES

The latest edition of the following standards and codes shall be applicable for the materials specified within the scope of this section:

- BS 31 - Steel conduits and fittings for Electrical Wiring.
- BS 4607 - Non-metallic conduits and fittings for electrical installations.
- BS 1387 - Galvanized Iron (GI) pipes and fittings.
- BS 3505 - uPVC pressure pipe and fittings.

4.0 MATERIAL

4.1 PVC Conduit and Accessories

The PVC conduits and accessories for lighting and power circuits shall be furnished by the Contractor as shown on the drawings or given in BOQ. The PVC bends shall have enlarged ends to receive conduit without any reduction in the internal diameter

at joint. Manufactured smooth bends shall be used where conduit changes direction. Bending of conduits by heating or otherwise will be allowed in special situations only for which the consent of the Engineer shall be required. The use of sharp 90 degree bends and tees will not be allowed for concealed wiring.

The round PVC junction boxes for ceiling light or fan points shall have minimum dimensions of 63 mm diameter and depth. The junction boxes for wall light points shall have minimum dimensions of 63 mm diameter and 38 mm deep. Round junction boxes shall be provided with one piece PVC cover plate fixed to the box by means of brass screws.

4.2 Inspection/Pull and Adaptable Boxes

Inspection/Pull boxes and adaptable boxes shall be provided in conduit runs wherever required to facilitate pulling operation. The drawings are diagrammatic and do not indicate the position and spacing of inspection/pull boxes or adaptable boxes. However, these shall be as per Engineer's approval.

4.3 uPVC Pipes and fittings

Unplasticized PVC pressure pipes and fittings shall conform to BS 3505:1968 and shall be of class-D (working pressure - 12 bars). The buried uPVC pipes should be able to withstand the external load acting upon it by continuous movements of heavy duty vehicles such as trucks, cranes, forklift etc. where pipe changes direction; manufacturer smooth bend shall be used.

Fittings and accessories for use with uPVC pressure pipes shall be of the same class and manufacture as the pipe and shall have the required shapes and dimensions of turned ends to fit the uPVC pressure pipes. uPVC pipes and accessories shall be suitable for jointing with rubber rings or solvent.

Bending of pipes by heating or otherwise will not be allowed. The use of sharp 90 degree bends and tees will not be allowed. The bends shall conform to same specifications as given for PVC conduits. For joining of pipe all precautions and procedures recommended by manufacturer shall be allowed.

Hard PVC or reinforced concrete pipe range spacers shall be used if there is more than one pipe running in parallel. The distance between range spacers shall be maximum 2 meters. Range spacers shall be prefabricated/precast and decay resistant.

Flexible pipes shall be used as deemed essential or as approved by the Engineer.

5.0 INSTALLATION

5.1 PVC Conduits and Accessories

5.1.1 Concealed Conduit

Where concealed conduit system is shown on drawings/ mentioned in BOQ, the conduit shall be installed concealed in roof, wall, column, etc. Conduits shall be laid under floor only where specifically stated. The entire conduit system shall be installed and checked before wiring is carried out. Any obstruction found shall be cleared before the installation of cable.

When concealed, the conduit shall have a minimum of 32mm cover of concrete measured from the top of conduit to finished surface. In the reinforced cement concrete (RCC) work the conduit shall be laid before pouring of concrete. Under no circumstances shall chases be made in the RCC structure for concealing conduit and accessories after pouring of concrete. The conduit shall be supported on top of bottom reinforcement of slab. All outlet boxes to be firmly supported and installed such that they finish flush with the soffit of slab or beam.

Where conduits have to be concealed in cement concrete (CC) work after concreting or in block masonry, chase shall be made with appropriate tools and shall not be made deeper than required. The conduit shall then be fixed firmly in the recess and covered with cement concrete mixture. The work of cutting in the cement concrete work or block masonry work shall be coordinated with the civil work. The Contractor shall obtain approval from the Engineer before starting chasing and cutting.

The termination of conduits at or near the equipment / switchboard is shown diagrammatically on the drawings. The exact locations of the termination shall be coordinated with the equipment/switchboard to be installed. Any extension of conduit to suit the site condition shall be made without any extra cost. Conduit ends pointing upwards or downwards shall be properly plugged in order to prevent the entry of foreign materials. All openings through which concrete may leak shall be carefully plugged in order to prevent the entry of foreign materials. All opening through which concrete may leak shall be carefully plugged and boxes shall be suitably protected against filling with concrete. At all terminations of conduit, sharp edges of conduit ends shall be prevented to avoid the cutting or damaging of wires or cables during pulling through the conduits.

Under floor conduit shall be installed at a minimum depth of 2 inch from the finished floor level or as shown on the drawings. The conduits shall be installed empty, before finishing of floor or in RCC work, with an 18 SWG steel wire drawn through the conduit for pulling cable. No conduits shall be laid under floor in bathroom.

5.1.2 Surface Conduits

The surface conduits shall be installed where shown on drawings mentioned in BOQ. The conduits shall be installed parallel or perpendicular to the surface of wall, structural members, ceiling, etc., by means of PVC saddles and clamps of approved design. The conduits shall be kept at least 150 mm away from parallel runs of flues, steam pipes and hot water pipes.

The saddles shall be installed on surface by means of nylon or wooden plugs and galvanized screws. Appropriate size of holes in structure shall be made by drilling; the thickness of saddles and clamps shall be at appropriate thickness and prime quality. The surface conduits shall be supported at maximum of one meter spacing along horizontal and vertical runs. The Contractor shall provide all accessories for complete installing of conduit system. The pull boxes, etc. as stated for concealed conduits shall also be applicable for surface conduit system.

5.2 uPVC Pipe and Fittings

uPVC pipes shall be installed as shown in the drawings. The depth of the pipe shall vary according to the conditions at site, and approval of Engineer shall be obtained prior to installation. In general the pipes shall be installed underground at the following depths measured from the top of the pipe.

- Under roads/pavement : 900 mm below finished surface.
- When crossing other services vertical/horizontal : 250/500 mm

The trench of required dimensions shall be excavated and the bottom of trench cleaned and leveled. A 100 mm bed of fine sand shall be provided over which the PVC pipes installed after proper alignment. Where two or more pipes are installed in the same trench the clearance between pipes shall not less than 50 mm. This shall be done by the provision of pipe range spacers as per Engineers approval. After lying of pipe the trench shall be backfilled with clean screened sand at least 100 mm above the top most pipes. The remaining portion of trench shall be backfilled with selected earth in layers well compacted.

After installation, the ends of the pipe shall be plugged with manufactured end cap impervious to water and chemicals. All joints shall be sealed adequately not only to prevent entry of foreign elements but also water tightness shall be ensured.

The installation of pipes shall be completed in all respects including its fixing at terminations, before cabling work is started. All sharp edges and burrs shall be removed by using reamer or any approved device. The pipe shall be through cleaned of dirt and dust from inside; the pipes shall be installed in proper co-ordination with other works.

The protective PVC pipe for cable entering building shall be installed so as to lead cable into the cable trench. The required number of pipes shall be fixed before completing the work in the plinth. If an opening is provided to the cable trench from outside, the required number of pipes shall be installed and part of the opening remained unutilized shall be properly packed and sealed using suitable packing material impervious to water and chemical to make it completely water-tight.

Spare pipes shall be provided with 5 mm dia rope pulled from end to end and plugged with manufactured end cap.

Flexible pipes of compatible material and size shall be used wherever deemed essential.

6.0 MEASUREMENT AND PAYMENT

6.1 General

The Contractors bid amount against each item of Bill of Quantities as given below shall include supply, installation, testing, commissioning and completion for all work specified herein and/or as shown on the Tender Drawings related to the item.

6.2 Conduits PVC / Pipes PVC and Accessories

6.2.1 Measurement

Measurement shall be made for the total running feet of each type and size of conduits / pipes and accessories acceptably supplied and installed by the Contractor according to specification and as shown on drawings.

6.2.2 Payment

Payment shall be made for the total running feet of each type and size of conduits or pipes measured as provided above at the contract unit price each and shall constitute full compensation for supplying, installing and completion of the laying of the conduits and pipes including all accessories related to the item.

No separate payments shall be made for the under mentioned specified work related to the supply and installation of conduit and pipe. The cost thereof shall be deemed to have been included in the quoted rates of above work.

- Excavation and backfilling.
- Dewatering during excavation and backfilling.
- Providing and filling of fine sand in trenches.
- Providing pipe range spacers.
- Providing flexible pipes and accessories, jointing material/compound, saddles, sockets, elbows, bend, junction boxes reducers, 16SWG GI pull wire for empty conduit, and 5 mm rope for empty pipe, soft metal bush, making threads and plugging of pipe with manufactured end cap etc. whether used or left spare.
- Compacted backfilling of trenches with specified material and disposal of surplus and rejected material.
- Watertight sealing of any unutilized opening to the buildings after installing the protective pipes entering the buildings.