



PAKISTAN INDUSTRIAL DEVELOPMENT CORPORATION (PIDC)

**“Development of Left-Over Infrastructure Development & Allied Works at
Naushahro Feroze Industrial Park, Naushahro Feroze”**

**(Road Network, Water Supply & Sewerage Network,
Electrical & Allied Works)**

Bidding Documents Volume - III

June 2025



BIDDING DOCUMENTS COMPRISE

Volume-I	Instructions to Bidders & Conditions of Contract,
Volume-II	Bill of Quantities
Volume-III	Technical Specification
Volume-IV	Drawings

All the above volumes are integral part of the Contract Documents and are to be read in conjunction with each other and are mutually explanatory of each other. In case of any contradiction, the provisions under Priority of Document and explanation of the Engineer shall be final and binding on the Contractor.

QUALITY CONTROL SHEET



QUALITY CONTROL SHEET				
DOCUMENT	Technical Specifications			
PROJECT	“(Infrastructure Development & Allied Works at Bin Qasim Industrial Park, Karachi Package-VIII (Road Network, Water Supply and Sewerage Network, Electrical Infrastructure))”			
CODE				
AUTHOR				
VERIFIED				
TO	Pakistan Industrial Development Corporation (PIDC)			
NOTES				

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PART - 1: GENERAL

SECTION - 1: GENERAL

1.1 SITE INFORMATION

The Contractor shall visit the site prior to making his bid and shall ascertain the nature of strata, the earth, its quality/quantity, locations, and suitability to meet the specified requirements, existing situation of working area and he shall base his bid estimates solely on his own studies and tests.

Any information about the properties of the soil that may be shown on the Drawings or obtained by the Contractor as a result of discussion with the Engineer or others shall be prejudice and shall not be considered as a valid basis for the Contractor's bid prices and subsequent execution and completion of works. The bore logs shown on the Drawings, if any, are tentative one and do not mean that the same strata will be involved during boring. The Contractor may carry out boring as per the actual strata at no additional cost to the Works.

1.2 LAYOUT

The layout of works for the purposes of execution of roads, water supply, sewerage, drainage and facilities under the scope of work shall be carried out by the Contractor subject to confirmation / check by the Engineer which must be accurately as per the Drawings and instructions of the Engineer. Before commencement of construction work, the layout shall be checked and certified by the Engineer's Representative or Engineer. The measurement for payment shall not be taken for this item of the work, price shall be deemed to be included in other items of Works.

1.3 SURVEY EQUIPMENT

The Contractor with the approval of the Engineer shall provide survey equipment for the Engineer's Representative and his staff which shall be of the number, type and quality (or equivalent) as listed in **Table 1.1**.

Table 1.1, List of Survey Equipment

Sr. No.	Equipment	Quantity
1	Total Station complete with Standard Accessories model SOKKIA SET 2010 or Equivalent	1-No.
2	Single Tilting Range Pole Prism Complete Set Model SOKKIA KPS 11 PT or Equivalent	1-Set
3	Single Tilting Prism W / Coaxial Target Complete Model SOKKIA KPS 12 or Equivalent	1-Set
4	Automatic Levels, with Standard Aluminium	2-Nos.

Sr. No.	Equipment	Quantity
	Tripod Model B20	
5	Steel Measuring Tapes 50m and 20m long	2-Each
6	Steel Measuring Tapes 3m long	6-Nos.
7	Levelling Staff (4m)	2-Nos.
8	Ranging Rods	as required
9	All Miscellaneous Tools, Equipment and Materials required in Surveying	as required

The cost of said survey equipment shall be deemed included in other items of works; as such no separate payment shall be made. All surveying equipment shall be new and maintained in perfect working condition throughout the contract period and replaced by the Contractor in case of damage or loss under the terms and condition of the agreement.

1.4 PLANT, EQUIPMENT AND TOOLS

The Contractor shall provide at his cost modern plant, equipment and tools, adequate and befitting to the nature, magnitude and size of this Contract, in strict compliance with the requirements of the Contract.

1.5 STORAGE & HANDLING FACILITIES

The Employer will provide the necessary space if available with him, for constructional activities including batching plant, laboratory, workshop, storage of plant, equipment and materials and for Contractor's temporary office/camp, during the currency of the Contract. If the space is ' not available with the Employer then the contractor shall arrange these facilities without additional cost to the Employer.

1.6 TEST LABORATORY TESTING AND TESTING REPORT

Testing, except as otherwise specified herein, shall be performed by testing agency approved by the Engineer and at no extra cost to the Employer. The Contractor shall bear the Cost of such Testing. The Engineer may require all or part testing to be carried out under his supervision only.

The quality control testing shall be performed by the Contractor's competent personnel in accordance with a site testing and quality control program to be established by the Contractor and approved by the Engineer. The Contractor shall keep a complete record of all quality tests performed on site.

All quality control and tests shall be carried out in accordance with applicable standards and codes.

1.7 PROTECTION OF THE WORKS

The Contractor shall whenever necessary cover up and protect the works from weather and damage by his own or other workmen performing subsequent operation at no extra cost to the Employer including all necessary dust sheets, barriers and guard rails and clear away the same on completion.

1.8 RESTORATION AND CLEANING

Upon completion of the works the Contractor shall restore all items covered by the Contract to the satisfaction of the Engineer.

The Contractor shall do regular cleaning and clean away all rubbish and excess materials that may accumulate from time to time on completion and before handing over. Upon completion of the Works, he shall obliterate all signs of temporary construction facilities such as work areas, structures, foundations of temporary structures, stock piles of excess or waste materials, as directed by the Engineer. Trash shall be removed daily to the satisfaction of the Engineer.

1.9 COORDINATION WITH OTHER WORKS

The Contractor shall coordinate with other Contractors executing other works in the project area or in the vicinity. The Contractor shall plan and schedule these activities in close liaison with other Contractors. The cost of this coordination will be deemed to be included in other items of works as such no separate payment is admissible for the coordination.

1.10 DEFINITIONS

Capitalized terms used in these specifications shall have the meanings specified in Volume-I, Condition of Contract, unless the context expressly or by necessary implication otherwise requires.

1.11 ABBREVIATIONS

Whenever, in these specifications, the following abbreviations are used, the intent and meaning shall be interpreted as follows:

°C	Degree Centigrade
°F	Degree Fahrenheit
AASHTO	American Association of State Highway and Transportation Officials
ASTM	American Society for Testing and Materials
ACI	American Concrete Institute
ASIC	American Institute of Steel Construction
ASCE	American Society of Civil Engineers

AWWA	American Water Works Association
BS	British Standards
BSI	British Standard Institute
CBR	California Bearing Ratio
cm	Centimetre
DIN	Deutsches Institut für Normung
EN	European Norm
HDPE	High Density Polyethylene Pipe
HP	Horse Power
ISO	International Standards Organization
JMF	Job Mix Formula
kg	Kilogram
km	Kilometre
lb	Pound
m	Metre
mm	Millimetre
PN	Pressure Nominal
WBM	Water Bound Macadam

PART - 2: EARTHWORK FOR ROADS

SECTION - 2: GENERAL

2.1 DESCRIPTION

Earthwork will consist of all necessary work for the excavation and placing in embankment or backfill or disposal by dumping of soil, rock or other material from or to the roadway or adjacent thereto or from borrow areas, including the excavation of side and interception ditches, the removal of unsuitable sub grade material, the formation of lay byes, the widening of cuts and the flattening of cut slopes whether to obtain material for embankments or backfill, or to increase the stability of the slopes, clearing and grubbing, the selective removal of trees, stripping and the removal of existing obstructions within the approved cross section for excavation, in accordance with these specifications and in conformity with the lines, grades, sections, and dimensions shown on the Drawings or as directed by the Engineer.

2.2 SOIL INFORMATION

Any information concerning the properties of the soil or sub soil and other geotechnical information shown on the drawing or other documents forming part of the contract is for information only. The Contractor is obliged to make his own assessment of site conditions prevailing. No claim for extra cost or time extension will be entertained based on the information provided.

The Contractor shall be deemed to have visited the site prior to making his bid and shall ascertain the nature of the soil and rock, its quantity, locations and suitability to meet the specified requirements, in particular the borrow pits, and he shall base his bid estimates solely on his own soil investigation. After the award of the contract no claim for a revision of bid prices depending on the sources of soil information will be entertained.

2.3 EXPLOSIVES

Where explosives are used the Contractor shall provide suitable buildings or warehouses in approved positions for the storage of explosives, which shall be stored in the manner and quantity approved by the Engineer or as per relative laws of government. Such storage places shall be accessible only to authorized personnel. They shall be properly marked; all doors or accesses thereto shall be constructed of materials as directed by the Engineer and provided with secure locks and all necessary means for preventing access by unauthorized persons. The Contractor shall be responsible for the prevention of any unauthorized issue or improper use of any explosives. The handling of explosives shall be entrusted only to experienced and responsible men, to the satisfaction of the Engineer, and in conformity with the statutory regulations.

All drilling and blasting shall be done in such a manner as to bring the

excavation as close as possible to the required cross sections, and to disturb as little as possible the material to be left in place. Blasting by means of drill holes, tunnels, or any other method shall be performed, at the entire risk and responsibility of the Contractor who shall have no claim to payment for extra work occasioned by breakage outside the approved cross-sections or dimensions.

The greatest care shall be taken by the Contractor during all blasting operations to ensure that no injury be done to persons or damage to property or to the finished work. Shots shall be properly loaded and capped, and only a moderate charge shall be used in each hole. A record of all explosives used, showing locations and amounts, shall be kept by the Contractor for checking by the Engineer.

Where directed by the Engineer, the Contractor shall provide heavy mesh blasting mat for protection of persons, property and the work. If necessary, blasting shall be restricted to time prescribed by the Engineer.

The Engineer may prohibit blasting and order the rock to be excavated by other means, if, in his opinion, it would be dangerous to persons or adjacent structures, or is being carried out in a reckless manner. If traffic on the road has to be interrupted, the Contractor shall obtain approval of his schedule for such interruption from the proper authorities and shall satisfy the Engineer that he has obtained it. No extra payment shall be admissible for such arrangements as described here above.

2.4 REMOVAL OF EXISTING OBSTRUCTIONS

The pay items under Section - 3:, Section - 4:, Section - 6:, Section - 7:, Section - 8: and Section - 9: shall include the cost of removal of all material regardless of its nature, encountered within the limits of the approved cross-section, including the removal and disposal, as required by the Engineer, of existing brick, stone, all types of concrete or masonry, rock boulders or fragments, old pavements, culverts, bridges, walls, buildings, roads or parts thereof, retaining walls or any other material encountered during the excavation, unless a separate item appears in the Bill of Quantities for such features.

2.5 REMOVAL OR DIVERSION OF WATER

Except where provided for, no separate payment will be made for control of or removal of water during or after earthwork operations. The cost of sheeting, shoring, cofferdams, pumping and draining shall be included in the bid prices for earthwork. The Contractor shall provide necessary facilities for dewatering and for draining or diverting watercourses when necessary for the protection of the contract work or where required by the Engineer.

The Contractor shall provide such drainage outlet ditches or canals as may be necessary to affect proper drainage before rain is expected. Such

drainage ditches or canals for protection of work during construction and their maintenance and clearing to make them continuously effective during the work shall not be paid separately, but shall be deemed to be included in other items of work.

The Contractor shall also provide, fix, maintain and operate such engines, pumps, hoses, chutes and other appliances as are necessary to keep the accumulated water at a level required for the safety of the structures as directed by the Engineer.

2.6 DITCHES

The Contractor shall construct side ditches, interception ditches, and inlet and outlet ditches as shown on the Drawings or where ordered by the Engineer, whether for temporary or permanent drainage. In order to keep water away from the embankment, sub-grade, and/or pavement during construction, the Contractor shall at all times ensure adequate drainage by scheduling ditch and outlet so that the drainage is operative before work is stated on the embankment, sub grade or pavement. He shall clean and trim all such drainage ditches from time to time, so that there may be a free flow of water throughout the whole period of the Contract. Ditches shall first be trimmed according to approved cross-sections, and final trimming, including the repair of any damage that may have been done during the construction work, shall be carried out after the completion of the other construction work and shall be a condition for final approval and acceptance.

Unless otherwise specified no separate payment will be made for the excavation of side ditches, interception ditches, inlet and outlet ditches but such payment will be made under Section - 6: or Section - 7:, whichever applicable.

Where indicated on the Drawings or when required by the Engineer, the Contractor shall take cross-sections of existing stream channels, and in collaboration with the Engineer, mark them with details of the excavation required for the relocation of the stream channel. Work shall not proceed without written approval of the marked cross-sections by the Engineer.

2.7 EXCAVATION FOR CULVERTS

Except where otherwise specified excavation and backfill for culvert and drainage pipes, except granular backfill to under drains, will not be paid for separately, but shall be considered as a subsidiary obligation of the Contractor covered under the contract price for the various classes of pipe culvert.

2.8 LANDSLIDES, BENCHES, FLATTENING OF SLOPES

The Engineer may order the removal of material resulting from landslides the construction of benches in or above the cut slope or in the embankment slope or where in his opinion the slope shows signs of instability, the flattening of the slope. Payment of all such work shall be at contract prices in Section - 7: or Section - 9:, as the case may be.

2.9 SURVEY & LEVELLING PRIOR TO COMMENCEMENT OF EARTHWORK

The Contractor shall be responsible for the setting out of the work in accordance with General Conditions of Contract. Notwithstanding those project Drawings; have been issued to the Contractor, he shall also be responsible for taking joint cross-sections on the proposed alignment of the road, submitting three copies of the plotted cross-sections and longitudinal profile to the Engineer and obtaining the approval of the Engineer to such cross-section and longitudinal profile before any work in connection with Earthwork is commenced. These cross-sections and longitudinal profile shall be in the form and manner as instructed in writing by the Engineer.

2.10 MEASUREMENT AND PAYMENT

The quantities of the various classes of excavation or embankment to be measured for payment under the contract shall be limited to the lines and level as taken under SECTION-2.9 above. However, if the levels so taken differ appreciably from design levels the matter shall be referred to the Employer.

Excavation and filling beyond the lines and level shown on the Drawings, approved profiles and cross-sections will not be paid for. The Engineer will decide the angle of the slope of cuts and fills as the work proceeds on the basis of evaluation of the soil characteristics. The actual lines of the cuts and fills as made will be duly measured and recorded by the Contractor. The Engineer will check these records and will approve the measurements, if correct, as a basis of payment. Excess of excavation shall be backfilled, as directed by the Engineer, with sub base material without extra payment to the Contractor; excess of fill may be either left in place or removed as required by the Engineer. The quantities of excavation, backfill and earthwork to be paid for in Section - 4: respectively shall be the number of cubic feet/meters of material measured by the average end area method, except where the error may exceed plus or minus five percent as compared with the prismatic formula in which case the Engineer will authorize the use of the more accurate method. However, the Contractor shall request such authority before he submits his quantities for approval. Quantities measured on the average end-area basis, once they have been submitted and approved, shall not be subject to review for the purpose of applying a more accurate method.

SECTION - 3: CLEARING AND GRUBBING

3.1 SCOPE OF WORK

This work shall consist of removal to the specified depth, grubbing and disposal of all surface objects, as and where directed in writing by the Engineer, stumps, roots, bushes and trees with less than 150 mm girth, vegetation, logs, rubbish and other objectionable material except such objects as are designated to remain or are to be removed in accordance with other section of specification.

3.2 CONSTRUCTION REQUIREMENTS

3.2.1 Clearing/Grubbing

In roadway cut areas, all surface objects or any object to the depth of 30 cm below subgrade level such as stumps, roots, vegetation, bushes, logs, rubbish shall be cleared and/or grubbed as directed by the Engineer. In roadway fill areas where clearing and grubbing is required, same shall be carried out to the depth of 30 cm below natural surface level as described above. If embankment is greater than 3 metres, then clearing and grubbing is not required.

Operation of clearing and grubbing shall in no way be deemed to affect any level or volume change of the area.

After clearing and grubbing, the compaction of the area will be restored to its original value without any extra payment. However, Engineer may direct in writing to the Contractor for stripping (if so required) under Section - 4: or for compaction under Section - 5: if the original compaction is less than the required for respective zone. Payment of these items will be made separately under the relative items used for such purpose.

Before bottom layer of embankment is placed, contractor will grub up and remove without extra payment, any vegetation that may, in the meantime have grown on surface previously cleared and grubbed.

All trees having girth less than 150 mm measured at 600 mm above ground and falling within the construction limits shall be felled & removed by the contractor. The excavation and removal of trees, roots and stumps including backfilling and compacting of holes and restoring the natural ground to the original condition shall be responsibility of the contractor for which no extra payment shall be made to him. The trees, stumps & roots remains the property of the Employer, which shall be delivered at designated place as directed by the Engineer.

3.2.2 Protection and Restoration

The Contractor shall prevent damage to all pipes, conduits, wires, cables or structure above or below ground. No land monuments, property markers, or official datum points shall be damaged or removed until the Employer/Engineer has witnessed or otherwise referenced their locations and approved their removal. The Contractor shall so control his operations as to prevent damage to shrubs, which are to be preserved. Protection may include fences and boards latched to shrubs, to prevent damage from machine operations. Any damage as a result of contractor's operation shall immediately be rectified by him at his own expense.

3.3 MEASUREMENT AND PAYMENT

3.3.1 Measurement

Clearing and grubbing will be measured for payment only on areas so designated in writing by the Engineer or shown on the Drawings. The quantity to be paid for shall be the number of square meters or square feet (whichever is included in Bill of Quantities) satisfactorily cleared and grubbed. Any tree having girth of less than 150 mm (measured 600 mm above ground level) shall be measured to be under this item.

Clearing and grubbing carried out by the Contractor in roadway cut areas and borrow pits shall not be measured for payment.

3.3.2 Payment

The quantities determined as provided above will be paid for at the contract unit price for the pay item as included in Bill of Quantities, which price and payment shall be full compensation for clearing and grubbing and restoration of area, to its original level and condition.

SECTION - 4: STRIPPING

4.1 SCOPE OF WORK

This work shall consist of removing unsuitable topsoil, transporting and depositing in stockpiles or spreading where indicated on the Drawings or as directed by the Engineer. Engineer shall give instruction in writing, stating area and depth to be stripped.

4.2 CONSTRUCTION REQUIREMENTS

The areas from which stripping of topsoil is required shall be as indicated on the Drawings or as directed by the Engineer. The Contractor shall remove topsoil from these areas to depth as directed by Engineer. Stripping of topsoil in any case shall be not less than 10 cm in depth. The removed topsoil shall be transported, deposited in stock piles at locations designated by the Engineer and/or spread where indicated on the Drawings or as directed by the Engineer. Engineer shall, however identify the soil as unsuitable through laboratory tests.

The top soil shall be placed separately from other excavated materials and be completely removed to the required depth from the area prior to the beginning of regular excavation or embankment work in that area. No payment will be made for topsoil removed from places other than that directed by the Engineer. Engineer shall, however identify the soil as unsuitable through laboratory tests, before such a decision.

4.3 MEASUREMENT AND PAYMENT

4.3.1 Measurement

Measurement shall be made by multiplying the length, breadth and depth of layer approved by the Engineer in cubic metre or cubic feet (whichever is included in Bill of Quantities) of material removed and disposed as directed by the Engineer. However, space thus created shall be filled by the material as directed by the Engineer and paid separately under relative item.

The stripping and replacement of the top soil in the area, if required and directed by the Engineer in the area cleared and grubbed, no measurement shall be done for item clearing and grubbing for direct payment. The cost of clearing and grubbing shall be deemed to be included in item of stripping.

4.3.2 Payment

The payment under this item shall be made for at the contract unit price for the pay item as included in Bill of Quantities, for removal of material to a depth approved by the Engineer including its disposal at designated place and in the manner as directed by the Engineer.

The cost of clearing and grubbing, in the area where stripping is required, shall not be paid separately, and its price shall be deemed to be included in the cost of stripping.

SECTION - 5: COMPACTION OF NATURAL GROUND

5.1 SCOPE OF WORK

The work shall consist of the compaction of the natural/original ground, the cleared and grubbed surface (i.e., the surface after clearing and grubbing), stripped surface after stripping and the excavated surface after excavation, prior to commencement of embankment in accordance with these specifications, as shown on the Drawings or as directed by the Engineer. The compaction shall be carried out through a written order by the Engineer.

5.2 CONSTRUCTION REQUIREMENTS

The natural ground / cleared and grubbed surface / stripped surface / excavated surface shall be broken up, ploughed and scarified for all sods and vegetable matter removed to a depth of 200mm and compacted to the degree as defined in Table 5.1.

Table 5.1, Compaction Requirements of Natural Ground

Sr. No.	Height of Embankment below sub-grade level	Percent of Maximum Dry Density determined by AASHTO T-180
1	0 to 30 cm	95
2	over 30 cm	93
3	below the foundation of structures	95

In the areas where ground water table is high or salinity exists, refer relevant section of these specifications.

5.3 MEASUREMENT AND PAYMENT

5.3.1 Measurement

The measurement shall be made by multiplying the length and breadth of the area approved in writing by the Engineer to be paid under this item. The measurement of the item shall be in square metre or square feet (whichever is included in Bill of Quantities).

Any subsidence of levels of Natural Ground due to compaction under this item shall not be measured for payment; the Contractor is expected to take care of such factors while bidding.

5.3.2 Payment

The payment under this item shall be made for at the contract unit price for square metre or square feet, as included in Bill of Quantities, of compaction of (natural) ground measured as above and shall be deemed to include cost of scarification, watering, mixing, levelling, rolling, labour, equipment, tools, and incidentals necessary to complete this item.

SECTION - 6: ROADWAY & BORROW EXCAVATION

6.1 SCOPE OF WORK

The work shall consist of excavating the roadway and borrow pits, removal and satisfactory disposal of all materials taken from within the limits of the work, also such excavation as is necessary for inlet and outlet ditches of structures and shall include all excavation (after stripping of top soil, if required), shaping and sloping for the construction, preparation of all embankment, sub-grade, shoulders, intersections and approaches as directed and in conformity to the alignment, grade, level and cross-sections shown on the Drawings or established by the Engineer. It shall include only material suitable for fill, backfill or for formation of the embankment.

6.2 CLASSIFICATION OF EXCAVATION

6.2.1 Roadway Excavation

Roadway Excavation shall comprise all excavation that is not classified as structural excavation carried out within the limits of roadway including permanent drainage ditches and side slopes in cut.

Roadway Excavation shall further, be classified as "Common Excavation", or "Rock Excavation", (common excavation shall include all the materials of whatever nature encountered but not including rock excavation).

A) Common Excavation

Common excavation shall consist of the removal and satisfactory disposal of all eolian, alluvial and residual materials, in place unaltered and un-weathered strata, which are not firm or rigid enough to possess all the characteristics of "Rock Excavation". Boulders of less than one quarter (1/4) cubic metre volume shall also be classified as "Common Excavation". Eolian and alluvial materials consist of gravel, shale, volcanic ash, loess, dunes and, loams, silts, sands and clays or any combination of these materials, and termed as Common Excavation.

B) Rock Excavation

This includes firm and rigid igneous, metamorphic and sedimentary rocks. Boulders larger than quarter (1/4) cubic metre in volume will also be considered as "Rock Excavation", provided these are firm and stable lying in continuous bed and constitute more than 50% by volume as compared to other type of materials in the total mass.

The classification of Hard, Medium or Soft Rock shall be same as described in SECTION-7.2.

6.2.2 Borrow Excavation

Borrow Excavation shall comprise all excavation taken from borrow pits. Material from borrow pits shall normally be used for the construction of embankment or for the backfill when there is no material available from roadway excavation or structural excavation. Permission to use material from borrow pit shall first be obtained in writing from the Engineer. Nevertheless, the total quantity of material from roadway excavation and structural excavation after deduction of the material declared unsuitable by the Engineer, shall be considered available for use in the work and any material used from borrow pits for formation of embankment in lieu thereof shall not be measured for payment.

In making his bid, the Contractor shall inspect the site and prepare his estimate of the haulage cost on the basis of his own survey of the possible nature and locations of the borrow pits. Their distance from the work sites shall not be grounds for extra payment or revision of the contract price.

The consent of the landowner or tenant for excavating the borrow material and hauling along private access roads shall be secured by the Contractor who shall, if required, pay for such concession. Borrow pits shall be left in a condition acceptable to the landowner and/or tenant and the Engineer. In particular, they will be left in a safe, free draining condition. In all areas, any topsoil previously removed, shall be reinstated, unless otherwise instructed by the Engineer.

6.2.3 Structural Excavation

The description, method of measurement and payment of this section shall conform to as specified in Section - 8:.

6.3 CONSTRUCTION REQUIREMENTS

All material removed from excavation shall be used in the formation of embankment, sub-grade, shoulders, and at such other places as directed, unless it is declared unsuitable and ordered to waste by the Engineer. No excavated material shall be wasted without written permission from the Engineer, and when such material is to be wasted, it shall be so placed that it will present a neat appearance and not offer any danger to abutting property.

The material shall be declared unsuitable if the soaked CBR (96 hours) is less than five (5) percent or if falls under A-6 or A-7 of AASHTO soil classification.

Wing construction of the roadway, the road bed shall be maintained in such a condition that it will be well drained at all times.

All slopes, except in solid rock or other material shall be trimmed precisely as per cross-sections, and care must be exercised that no material shall be

loosened beyond the required slopes. In blasting rock slopes, a reasonably uniform face shall be left, regardless of whether or not the excavation is carried beyond the specified side slope. All breakage and slides shall be removed by the Contractor and disposed of as directed by the Engineer.

Unsuitable road bed material encountered in cuts shall be excavated to required width and depth indicated on the Drawings or as otherwise directed. Any over breakage below the depth shown on the Drawings will not be paid for. Backfill of the overcut shall be of approved earth material and shall have the same density requirements as specified on the Drawings and shall be at the expense of Contractor.

Borrow pits, if located within the project area, shall be so located that the nearest edge of the pit is at least thirty (30) meters from the roadway toe of slope unless otherwise directed by the Engineer.

Permission to use any borrow material, including its suitability, shall be obtained in writing from the Engineer before execution of work. It is responsibility of the Contractor to submit a request for test at least fifteen (15) working days prior to the day the Contractor intends to begin taking material from the borrow area.

Borrow material shall not be obtained less than two kilometres downstream of any hydraulic structure. However, the borrow pit may be established at five hundred (500) meters upstream of the hydraulic structure. The side slopes of the pits or channels shall be constructed as shown on the Drawings or directed by the Engineer. In no case the side slopes of borrow pit be steeper than a slope; 1:5 (V:H).

Upon abandonment of borrow pit or quarry area, the Contractor shall, at his own expense, clean and trim the borrow pit or quarry area, the right of way, and adjoining properties which were occupied during execution of work, all to the satisfaction of the Engineer.

All drilling and blasting shall be done in such a manner as will most nearly, complete the excavation to the required grade line, and produce the least disturbance of the material to be left in place. Blasting by means of drill holes or any other methods shall be performed at the entire risk and responsibility of the Contractor. Care shall be taken to ensure that no injury be done to persons or properties or to the finished work. Blasting shall be restricted to the hours prescribed by the local authorities or the Engineer.

Where between two successive cross-sections of the road, the properties of rock boulders, in sizes larger than a one quarter ($1/4$) of a cubic metre, to earth is more than 50%, the excavation will be considered wholly as rock.

Rock material above ground level such as stones, boulders, piles of stone, and dry stones walling whose individual sizes are greater than one quarter of a cubic metre shall be removed and disposed of if directed in writing by the

Engineer and shall be paid under relevant item of work in the Bill of Quantities.

6.4 MEASUREMENT AND PAYMENT

6.4.1 Measurement

When the Bill of Quantities specifies for "Common Excavation", "Rock Excavation" and "Borrow Excavation" the quantities of the different classes of excavation shall be computed as follows:

A) Common Excavation

The unit of measurement for common excavation shall be in cubic metre or cubic feet (whichever is included in Bill of Quantities) and be computed by average end area method based on cross-sections duly approved by the Engineer prior to commencement and completion of required excavation.

The excavated material approved for fill under any item of the Bill of Quantities shall be used in the manner as described under the relevant item of work, irrespective of haulage distance.

B) Rock Excavation

Authorized "Rock Excavation" to be measured in in cubic metre or cubic feet (whichever is included in Bill of Quantities) shall consist of area that is necessary to provide the design section and grade or as directed by the Engineer. Any over breakage beyond the lines shown on the Drawings and outside of the tolerances set for subgrade in cuts shall not be paid for. The Engineer shall define the beginning and ending points of areas classified as "Rock Excavation". Any area over excavated in the subgrade shall be reinstated at the cost of Contractor as directed by the Engineer.

The pay quantity for "Rock Excavation" shall be computed by means of average end area method from approved cross-sections based on original ground elevations after the authorized removal of unsuitable or overburden materials, if required.

For disposal of excavated rock material, same procedure shall be followed as described above for the "Common Excavation" specified in SECTION-6.4.1 (A)), above.

C) Borrow Excavation

No measurement shall be made for any Borrow Excavation, however this material if used in any of the Bill items, shall be measured and paid as provided under the relative items of work.

6.4.2 Payment

No payment for Roadway or Borrow Excavation shall be made under this item as the same is deemed to be included under relative item of Section - 9:, FORMATION FOR EMBANKMENT.

SECTION - 7: EXCAVATION OF UNSUITABLE/SURPLUS MATERIAL

7.1 SCOPE OF WORK

The work shall consist of excavation and disposal of unsuitable or surplus material arising from roadway excavation, which is declared in writing by the Engineer to be unsuitable for use or surplus to the requirements of the project. When excavation of unsuitable material requires special attention for a known condition on a specific project then construction requirements and payment shall be covered under relevant Provisions.

7.2 CONSTRUCTION REQUIREMENTS

All suitable material excavated within the limits and scope of the project shall be used in the most effective manner for the formation of the embankment, for widening of roadway, for backfill, or for other work included in the contract.

Any material surplus to these requirements or any material declared in writing by the Engineer to be unsuitable shall be disposed of and levelled in thin layers by the Contractor outside the right of way within 7 km of excavation. The Engineer shall decide regarding the unsuitability of the material by conducting appropriate laboratory tests.

When unsuitable materials are ordered to be removed and replaced, the soil left in place shall be compacted to a depth of twenty (20) cm to the density prescribed under SECTION-9.3.1. Payment for such compaction shall be included in the contract prices for the excavation materials.

If the unsuitable material, which is to be removed, is below standing water level and the replacement material is gravel or a similar self-draining material of at least thirty (30) cm in depth, the compaction may be dispensed with if approved by the Engineer. Rock excavation shall be classified as under:

A) **Hard Rock**

Any rock which cannot be removed with Ripper of a 200 HP Bulldozer and constitutes a firm and continuous bed of rock only.

B) **Medium Rock**

Any rock which cannot be removed with the blade of 200 HP Bulldozer but can be removed by the ripper, will be termed as Medium Rock, irrespective of the fact that it is removed by blasting.

C) **Soft Rock**

Any rock which can be removed with the blade of a 200 HP Bulldozer. This item will be termed as Soft Rock, irrespective of the fact that it is removed by blasting.

7.3 MEASUREMENT AND PAYMENT

7.3.1 Measurement

When the contractor is directed to excavate unsuitable material below the surface of original ground in fill areas, the depth to which these unsuitable materials are to be removed will be determined by the Engineer. The contractor shall schedule his work in such a way that authorized cross sections can be taken before and after the material has been removed. Only material which is surplus to the requirements of the project or is declared in writing by the Engineer to be unsuitable will qualify for payments under this section.

The cost of excavation of material which is used anywhere in the project shall be deemed to be included in the pay Item relating to the part of the work where the material is used.

The pay Item shall include the cost of obtaining the consent of the owner or tenant of the land where the disposal of surplus or unsuitable material is made.

Unsuitable or surplus material shall be measured in its original position and its volume shall be calculated in cubic meters using end area method.

7.3.2 Payment

The quantities determined as provided above shall be paid for at the contract unit price for cubic metre or cubic feet, as included in Bill of Quantities, which prices and payment shall constitute full compensation for all costs involved in the proper completion of the work prescribed in this item.

SECTION - 8: STRUCTURAL EXCAVATION AND BACKFILLING

8.1 SCOPE OF WORK

Structural excavation shall include the removal of all material of whatever nature, necessary for the construction of foundations of bridges, culverts, retaining walls, headwalls, wing walls, catch basins, manholes, inlets and other structures not otherwise provided for in these specifications and in accordance with the Drawings or as directed by the Engineer. It shall include the furnishing of all necessary equipment and construction of all cribs, cofferdams, caissons, dewatering, sheeting, shoring etc., which may be necessary for the execution of the work. It shall also include the subsequent removal of cofferdams and cribs and the placement of all necessary backfill as hereinafter specified. It shall also include the disposing of excavated material, which is not required for backfill, in a manner and in locations so as not to affect the carrying capacity of any channel and not to be unsightly.

Only excavation below original ground and filling with approved material shall be paid under this item. Common backfilling with approved material above the level of the original ground line proposed in the Drawings or as asked by the Engineer shall be paid under relevant Bill of Quantities item(s).

8.2 MATERIAL REQUIREMENT FOR BACKFILL

8.2.1 Backfill Around Structure

Backfill around structure shall be made with the following material.

- Granular backfill of selected material as specified hereunder.
- Common backfill shall be carried out from excavated material or any other borrow material approved by the Engineer.

8.2.2 Granular Backfill

Granular backfill material shall meet the following requirements.

- Grading Requirement

The grading requirement for granular backfill are included in Table 8.1.

Table 8.1, Grading Requirements for Granular Backfill

Sr. No.	Sieve Designation		Mass Percent Passing	
	mm	inch	Grade-A	Grade-B
1	25	1	100	100
2	19	3/4	60-100	75-100
3	4.75	No.4	50-85	55-100
4	2	No.10	40-70	40-100
5	0.425	No.40	25-45	25-50
6	0.075	No.200	0-15	5-15

- b. Material satisfying the requirements of coarse sand falling under soil classification A-3 (AASHTO). In case, coarse sand is utilized for granular fill it shall be ensured that the same is confined properly with approved material.
- c. The material shall have a Plasticity Index of not more than six (6) as determined by AASHTO T-89 and T-90.

8.2.3 Common Backfill

Use of excavated material as backfill may be allowed under this item. Use of borrow material for common backfill shall be allowed on condition that the material requirements in SECTION-9.2 are followed and subject to approval of borrow material by the Engineer.

8.2.4 Rock Backfill

Rock material of small size shall be permitted in the backfilling of structures or walls subject to the approval of methodology by the Engineer.

8.3 CONSTRUCTION REQUIREMENTS

8.3.1 Structural excavation

A) General

All substructures, where practicable, shall be constructed in open excavation and, where necessary, the excavation shall be shored, braced, or protected by cofferdams in accordance with approved methods. When footings can be placed in the dry without the use of cribs or cofferdams, back forms may be omitted with the approval of the Engineer, and the entire excavation filled with lean concrete to the required elevation of the top of the footing. The additional concrete shall be at the expense of the Contractor.

In case the contractor has excavated additional volumes than specified thereunder, the contractor shall at his own expense backfill the volume with approved material as directed by Engineer.

The classification of Hard, Medium or Soft Rock shall be same as described under SECTION-7.2.

B) Preservation of channel

Unless otherwise specified, no excavation shall be made outside of caissons, cribs, cofferdams, piling, or sheeting, and the natural stream bed adjacent to the structure shall not be disturbed without permission from the Engineer. If any excavation or dredging is made at the site of the structure before caissons, cribs or cofferdams are in place, the Contractor shall, without extra charge, after the foundation base is in place, backfill all such excavation to the original ground surface or river bed with material approved by the Engineer. Material deposited within the stream area from foundation or other

excavation or from filling of cofferdams shall be removed and the stream bed freed from obstruction thereby.

C) Depth of Footings

The elevation of the bottoms of footings, as shown on the Drawings, shall be considered as approximate only and the Engineer may order, in writing, such changes in dimensions or elevation of footings as may be necessary to secure a satisfactory foundation.

D) Preparation of Foundations of Footings

- All rock or other hard foundation material shall be freed from all loose material, cleaned and cut to a firm surface, either levelled, stepped, or roughened, as may be directed by the Engineer.
- When masonry is to rest on an excavated surface other than rock, special care shall be taken not to disturb the bottom of the excavation, and the final levelling of the grade shall not be made until just before the masonry is to be placed.
- Foundation material on which structure is to be placed shall be compacted to 95% modified AASHTO T-180 density, unless otherwise directed by the Engineer. In case unsuitable material is encountered at foundation level, it shall be removed to the depth and extent as directed by the Engineer and replaced with suitable material of the type as determined by the Engineer.

E) Cofferdams and Cribbs

- For substructure work, the contractor shall submit, upon request, drawings showing his proposed method of cofferdams construction and other details left open to his choice or not fully shown on the Engineer's Drawings. The Contractor shall not start work until the Engineer has approved such Drawings.
- Cofferdams and cribbs for foundation construction shall be carried to adequate depths and heights, be safely designed and constructed, and be made as water tight as is necessary for the proper performance of the work which must be done inside them. In general, the interior dimensions of cofferdams and cribbs shall be such as to give sufficient clearance for the construction of forms and the inspection of their exteriors, and to permit pumping outside the forms. Cofferdams or cribbs, which are tilted or moved laterally during the process of sinking, shall be righted, reset, or enlarged so as to provide the necessary clearance and this shall be solely at the expense of the Contractor.
- When conditions are encountered which, in the opinion of the Engineer, render it impracticable to dewater the foundation before

placing masonry, he may require the construction of a concrete foundation seal of such dimensions as may be necessary. The foundation water shall then be pumped out and the balance of the masonry placed in the dry. When weighted cribs are employed and the weight is utilized to partially overcome the hydrostatic pressure acting against the bottom of the foundation seal, special anchorage such as dowels or keys shall be provided to transfer the entire weight of the crib into the foundation seal. During the placing of a foundation seal, the elevation of the water inside the cofferdam shall be controlled to prevent any flow through the seal, and if the cofferdam is to remain in place, it shall be vented or ported at low water level.

- Cofferdams or cribs shall be constructed so as to protect green concrete against damage from a sudden rising of the stream or river and to prevent damage to the foundation by erosion. No timber or bracing shall be left in cofferdams or cribs in such a way as to extend into the substructure masonry without written permission from the Engineer.
- Unless otherwise provided, cofferdams or cribs with all sheeting and bracing shall be removed after the completion of the substructure, care being taken not to disturb or otherwise injure the finished masonry.

F) Pumping

- Pumping from the interior of any foundation enclosure shall be done in such a manner as to preclude the possibility of the movement of water through any fresh concrete. No pumping of water will be permitted during the placing of concrete or for a period of at least twenty-four (24) hours thereafter, unless it is done from a suitable sump pit separated from the concrete work by a watertight wall or other effective means.
- Pumping to unwater a sealed cofferdam shall not commence until the seal has set sufficiently to withstand the hydrostatic pressure.

G) Inspection

After each excavation is completed the Contractor shall notify the Engineer, and no concrete or masonry shall be placed until the Engineer has approved the depth of the excavation and the character of the foundation material.

H) Classification of Excavation

Classification of excavation shall be made as described under SECTION-7.2.

8.3.2 Excavation in Embankments

Unless otherwise specified, the Contractor may choose with the approval of the Engineer to excavate for structures, culverts, and pipe culverts after the

embankment has been placed. Any space remaining after the placing of such structures or culverts shall be filled with material approved by the Engineer and compacted as follows:

Layers of not more than 15 cm in loose thickness shall be placed and compacted in succession, with mechanical tampers, plate compactors or hand guided rollers operated transversely to the roadway, to the densities specified in SECTION-9.3.1. Moisture content shall be adjusted as directed by the Engineer. Proper benching shall be made to ensure bonding of existing and new material without any extra payment.

The excavation in embankment and the placing of backfill for the purposes described above shall not constitute any claim for payment except where granular backfill is specified by the Engineer. Also, if sand or granular backfill is used by the contractor for his convenience, no extra payment will be made.

8.3.3 Backfill

- a) Granular backfill where-ever directed shall be placed in the position and to the required depth, shown on the Drawings or where and as required in writing by the Engineer and it shall be well compacted in layers not exceeding 15 cm in thickness to 100 percent of Max. dry density as per AASHTO T-180 (D). In case of water-logged areas, the thickness of the layer shall not exceed fifty (50) centimetres or as directed by the Engineer. Volume of granular fill around structures shall be calculated within the vertical limits of approved excavation for such a structure, whereas the horizontal limits shall be those as specified on Drawings.
- b) Common backfill shall consist of earth free from large lumps, wood and other organic materials and of a quality acceptable to the Engineer. It shall be placed in the position and to the required depths shown on the Drawings and/or as required in writing by the Engineer and it shall be well compacted in layers not to exceed 15 cm in depth to the density, 95 percent of maximum dry density, as per AASHTO T-180 (D).
- c) The rock backfill material whose individual sizes are not more than 30 cm shall be placed in the position to the required depth as specified and the voids shall be filled in layer of fine material approved by the Engineer. The compacting efforts shall be made so as to achieve the desired compaction approved visually by the Engineer. The depth of the layer in any case shall not exceed sixty (60) centimetres. However, in water logged areas, the thickness may be increased as directed by the Engineer. Rock backfill will not be placed within two meters from concrete face of any structure.

- d) All spaces excavated and not occupied by abutments, piers or other permanent work shall be refilled with earth or granular fill as approved by the Engineer up to the surface of the surrounding ground, with a sufficient allowance for settlement. All such backfill shall be thoroughly compacted and, in general, its top surface shall be neatly graded.
- e) The fill behind abutments and wing walls of all bridge structures shall be deposited in well-compacted, horizontal layers not to exceed 15 cm in thickness. The common backfill in front of such units shall be placed first to prevent the possibility of forward movement.
- f) Special precautions shall be taken to prevent any wedging action against the masonry, and the slope bounding the excavation for abutments and wingwalls shall be destroyed by stepping or roughening to prevent wedge action. Jetting of the fill behind abutments and wingwalls will not be permitted.
- g) Fill placed around culverts and piers shall be deposited on both sides to approximately the same elevation at the same time. Where the Contractor does not have proper equipment to ensure compaction in restricted areas, Engineer may allow backfill with sand saturation method, at no extra cost to the Employer.
- h) Adequate provision shall be made for the through drainage of all backfill. French drains shall be placed as weep holes.
- i) No backfill shall be placed against any concrete or masonry structure until permission has been given by the Engineer and preferably not until the concrete or masonry structure has been in place for minimum fourteen (14) days or until test cylinders show the strength to be 80% of the 28-days cylinder strength as included in SECTION-35.5.2. The backfilling shall be carried out on both sides of the structure simultaneously.

8.4 MEASUREMENT AND PAYMENT

8.4.1 Measurement

A) Structural Excavation

The quantities of structural excavation to be paid for shall be the number of cubic meters or cubic feet (whichever is included in Bill of Quantities) of material measured in its original position computed by the average end-area method, and excavated to the satisfaction of the Engineer.

Structural Excavation will be classified for measurement and payment as "Structural Excavation in Common Material", "Structural Excavation in Common Material Below Water Level", "Structural Excavation in Rock

Material" and according to whether the excavation is in earth or rock and according to whether the excavation is above or below the water level which is the constant level to which the water naturally rises in a foundation pit.

The volume of earth or rock to be measured for structural excavation shall consist of a prismoid bounded by the following planes:

- The vertical limits for computing pay quantities will be vertical planes 30 centimetres outside of the neat lines of footings or foundations as shown on the Drawings or as directed by the Engineer. Neat lines of footings or foundation shall mean the outer faces of footing or foundation excluding lean concrete.
- The upper limit for payment of structural excavation shall be the ground surface as it existed prior to the start of construction operations, except where structural excavation is performed within roadway excavation or ditch excavation areas, the upper limit shall be the planes of the bottom and side slopes of said excavated areas.
- The lower limits for computing pay quantities of structural excavation or structure backfill shall be a plane at the bottom of the completed footings, foundations, structures or lean concrete.

Measurement for structural excavation shall not include material removed below the footing grade and beyond specific limits to compensate for anticipated swell or as a result of effective swell during pile driving, or additional material resulting from slides, slips, cave-ins, silting or fillings, whether due to the action of the elements or to carelessness of the Contractor. The depths of the footings shown on the Drawings are approximate only and any variation found to be necessary during construction shall be paid for at the contract unit price.

B) Granular Backfill

The quantities of Granular Backfill to be paid for shall be the number of cubic meters or cubic feet (whichever is included in Bill of Quantities) of material laid and compacted in place within the line of structure and limits defined in SECTION 8.4.1 (A)) above, computed and accepted by the Engineer.

C) Common Backfill

The quantities of Common Backfill to be paid for shall be the number of cubic meters or cubic feet (whichever is included in Bill of Quantities) of material laid and compacted, placed within the lines of structure and limits defined in SECTION 8.4.1 (A)) above and accepted by the Engineer.

No separate payment shall be made for compaction of excavated surface for foundation under structures.

8.4.2 Payment

The quantities determined as provided above shall be paid for at the contract unit price, cubic meters or cubic feet (whichever is included in Bill of Quantities), which price and payment shall be full compensation for all the costs involved in the proper completion of the work prescribed in this item.

SECTION - 9: FORMATION FOR EMBANKMENT

9.1 SCOPE OF WORK

This work shall consist of formation of embankment, including preparation of area for placing and compaction of embankment material in layers and in holes, pits and other depressions within the roadway area in accordance with the specifications and in conformity with the lines, grades, thickness and typical cross-section shown on the Drawings or established by the Engineer. The work shall also include the compaction, trimming and shaping of side slopes as shown on the Drawings.

9.2 MATERIAL REQUIREMENTS

Material for embankment shall consist of suitable material excavated from borrows, roadway excavation or structural excavation and shall include all lead and lift. Borrow material will be used only when material obtained from roadway or structural excavation is not suitable or is deficient for embankment formation and shall include all lead and lift.

The material under this item shall conform to the following specification.

- a. Contractor shall use AASHTO Class A-1, A-2, A-3, A-4 or A-5 soil as specified in AASHTO M-145 or other material approved by the Engineer.
- b. CBR of the fill material shall not be less than the value as shown on the Drawings, determined in accordance with AASHTO T-193. CBR value shall be obtained at a density corresponding to the degree of compaction of that layer.
- c. Swell value of the material for embankment formation shall not exceed 0.50 percent. However, while establishing the swell value, surcharge weights representing the overburden will be used. In case sandy material is used for embankment formation, it shall be properly confined at no extra payment with a material and to the extent as approved by the Engineer and sandy material shall not be used on slopes of embankment.
- d. In areas subject to flood and prolonged inundation of the embankment, such as at bridge sites, the material used in embankment, unless rock, shall be AASHTO Class A1 (a), A1 (b) and A-2-4, Soils. Other soils may be used only with the written consent of Engineer.
- e. The following, for the purpose of embankments and sub-grade, shall be constructed as unsuitable materials:

- Materials from soil AASHTO classification group of A6 and A7;
- Materials from swamps, marshes and bogs;
- Peat, logs, stumps and perishable materials
- Materials susceptible to spontaneous combustion;
- Materials having a moisture content greater than the maximum permitted for each material in the Contract or as directed by the Engineer.
- Organic soils and containing all other deleterious substances.

9.3 CONSTRUCTION REQUIREMENTS

9.3.1 Formation of Embankment with Common Material

Material for embankment, obtained and approved as provided above, shall be placed in horizontal layers of uniform thickness and in conformity with the lines, grades, sections and dimensions shown on the Drawings or as required by the Engineer. The layers of loose material other than rock shall be not more than 15 cm thick, unless otherwise allowed by the Engineer after a trial section is prepared and approved for each material source or borrow area.

The material placed in layers and that scarified to the designated depth for formation of embankment shall be compacted to the density as specified in Table 9.1.

Table 9.1, Compaction Requirements of Embankment

Sr. No.	Depth in centimeters below sub-grade Level	Percent of Maximum Dry Density determined by AASHTO T-180*
1	0 to 30	95
2	Over 30	93

* Method 'B' or 'D' whichever is applicable, or corresponding Relative Density in case of sand fill.

In-place density determinations of the compacted layers shall be made in accordance with AASHTO T-191 or other approved methods. For all soils, with the exception of rock fill materials, containing more than 10% oversize particles (retained on 3/4 inch or 19 mm sieve), the in-place density thus obtained shall be adjusted to account for such oversize particles or as directed by the Engineer. Subsequent layers shall not be placed and compacted unless the previous layer has been properly compacted and accepted by the Engineer.

Material for embankment at locations inaccessible to normal compacting equipment shall be placed in horizontal layers of loose material not more than 15 centimetres thick and compacted to the densities specified above by the use of mechanical tampers, or other appropriate equipment.

The compaction of the embankment shall be carried out at the designated moisture content consistent with the available compacting equipment.

Embankment material that does not contain sufficient moisture to obtain the required compaction shall be given additional moisture by means of approved sprinklers and mixing. Material containing more than the optimum moisture may not, without written approval of the Engineer, be incorporated in the embankment until it has been sufficiently dried out. The drying of wet material may be expedited by scarification, disking or other approved methods.

When materials of widely divergent characteristics, such as clay and chalk or sand, drawn from different sources, are to be used in the embankment they shall be deposited in alternate layers of the same material over the full width of the embankment to depths approved by the Engineer. Rock, clay or other material shall be broken up, and no accumulation of lumps or boulders in the embankment will be permitted. No surplus material shall be permitted to be left at the toe of embankment or at the top of cut sections. Side slopes shall be neatly trimmed to the lines and slopes shown on the Drawings or as directed by the Engineer, and the finished work shall be left in a neat and acceptable condition. In order to prevent erosion of the slopes the Contractor shall compact the trimmed slopes to the required density prior to laying of top soil, if required and/or directed by the Engineer.

9.3.2 Formation of Embankment with Rock Material

Embankment formed of material consisting predominantly of rock fragment of such size that the material cannot be placed in layers of the thickness prescribed without crushing, pulverizing or further breaking down the pieces, such material may be placed in layers not exceeding in thickness than the approximate average size of the rocks except that no layer shall exceed eighty (80) centimetres of loose measurement and compacted by a vibratory roller with the minimum mass as shown in Table 9.2.

Table 9.2, Mass per Meter Width of Vibrating Roll for Rock Material

Sr. No.	Mass per metre width of vibrating roll, kg/m	Depth of fill layer (mm)	Number of passes of the roller on each layer
1	2300 – 2900	400	5
2	2900 – 3600	500	5
3	3600 – 4300	600	5
4	4300 – 5000	700	5
5	> 5000	800	5

The material shall be carefully placed in layers, so that all larger stones will be well distributed and voids completely filled with smaller stones, shale, earth, sand, gravel, to form a solid mass. After placing rock material, surface shall be covered with a layer of fine material having thickness less than twenty (20)

centimetres. Such fine material shall be reserved from roadway excavation by the Contractor. Should such material be available but not reserved, Contractor will supply and place borrow material for forming smooth grade without extra payment.

Each layer shall be bladed or levelled with motor grader, bulldozer or similar equipment capable of shifting and forming the layer into a neat and orderly condition. No rock larger than eight (8) centimetres in any dimension shall be placed in the top thirty (30) centimetres of embankment unless otherwise allowed by the Engineer.

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 one (1) percent of the layer thickness. In evaluation of settlement, survey points should be established and rolling continued until difference of levels as checked after two consecutive passes is less than one (1) percent of the total layer thickness. More over initial rolling of overlaid fine material shall be done without watering to ensure their intrusion in voids of rock layer beneath. Watering shall be done when voids are properly filled.

Embankments, which are formed of material that contain rock but also contain sufficient compactable material other than rock or other hard material to make rolling feasible, shall be placed and compacted in the manner prescribed above and to the point when settlement is within above mentioned requirement. Compaction test will be made whenever the Engineer determines they are feasible and necessary. Each layer must be approved by the Engineer before the next layer is placed.

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 fifty (50) percent of the thickness of the layer being placed.

9.3.3 Formation of Embankment on Steep Slopes

Where embankments are to be constructed on steep slope, hill sides or where new fill is to be placed and compacted against existing pavement or where embankment is to be built along one half the width at a time, the original slope of the hill side, of existing pavement or adjacent to half width of embankment shall be cut in steps of twenty (20) centimetres depth. Benching shall be of sufficient width to permit operation of equipment possible during placing and compaction of material.

Cut material shall be incorporated with the new embankment material and compacted in horizontal layers. No extra payment will be allowed for such an operation.

9.3.4 Formation of Embankment on Existing Roads

Before fill is placed and compacted on an existing roadway, the existing

embankment and/or pavement may be levelled by cutting, rooting or scarifying by approved mechanical means to a level to be determined by the Engineer. The earth, old asphalt or other material arising as a result of this operation will be declared either suitable or unsuitable, for use in the embankment or other items, by the Engineer. If the material is declared suitable it will be measured under relative item and if it is declared unsuitable, it will be measured under Section - 7:.

9.3.5 Formation of Embankment in Water Logged Areas

Where embankments are to be placed in water logged areas and which are inaccessible to heavy construction equipment, a special working platform shall be first established, consisting of a blanket of fill material placed on top of the soft layer. The material of the working table shall consist of normal or processed granular fill, obtained from borrow excavation. This material shall conform to the specifications as included in Table 9.3.

Table 9.3, Specifications for Embankment in Water Logged Area

Sieve Description	Percentage of Weight Passing Mesh Sieve, AASHTO T-27
3-inch (75 mm)	100

The remaining grading shall be such as to avoid intrusion into the working platform material of sub grade or natural ground surface material. For this condition to be met it will be required that the ratio:

$$\frac{D15 \text{ (Working Platform Material)}}{D85 \text{ (Natural Ground Material)}} \text{ is less than } 5$$

D85 and D15 mean the particle diameters corresponding to 85% and 15%, respectively, passing (by weight) in a grain size analysis.

Construction of this working table shall proceed from one edge of the soft area by using the fill as a ramp for further material transport.

The thickness of the working table as prescribed above shall be approximately 0.5 metre unless directed otherwise by the Engineer. And the width shall be that of the embankment. The placement and compaction of the working table shall be carried out by use of light equipment, as directed by the Engineer.

No density requirements are specified for the working platform; however, subsequent layers above it shall be compacted to the densities specified in SECTION-9.3.1.

Irrigated areas, such as rice fields and fish farms or natural ponds through which embankments are to be placed, shall be drained or kept drained of all surface water prior to commencing with placing of fill and all clearing and grubbing shall be performed, manually if necessary, in accordance with the

relevant articles.

In those areas of high-water levels and salinity with soft subsoil and where embankments area high such as approach fills to structures, special provisions shall be made to measure and determined likely fill settlements which may occur. These preconditions are necessary and to establish the time at which the pavement structure can be placed to avoid cracks and subsidence of these layers.

9.3.6 General Requirements

To avoid interference with the construction of bridge abutments and wing walls, the Contractor shall at points determined by the Engineer, suspend work on embankments and/or in cuts forming the approaches to any such structure until such time as the construction of the later is sufficiently advanced to permit the completion of the approaches without the risk of interference or damage to the bridge works. The cost of such suspension of work shall be included in the contract unit prices for embankment. In carrying embankments up to or over bridges, culverts or pipe drainage, care shall be taken by the Contractor to have the embankments brought to equally on both sides and over the top of any such structure. Contractor shall make special arrangements to ensure proper compaction in restricted spaces and around structures. No compensation shall be made to the Contractor for working in narrow or otherwise restricted areas.

When as a result of settlement, an embankment requires the addition of material up to 30 cm in thickness to bring it up to the required grade level, the top of the embankment shall be thoroughly scarified before the additional material is being placed, without extra payment to Contractor for the scarification.

The Contractor shall be responsible for the stability of all embankments and shall replace any portions that in the opinion of the Engineer have been damaged or displaced due to carelessness or neglect on the part of the Contractor. Embankment material which may be lost or displaced as a result of natural causes such as storms, cloud-burst or as a result of unavoidable movement or settlement of the ground or foundation upon which the embankment is constructed shall be replaced by the Contractor with acceptable material from excavation or borrow. No additional compensation will be allowed for the replacement.

Embankment filling shall be brought up and compacted over the full width of the embankment in one operation in layers parallel with the sub-grade level. At no time shall any part of the embankment width be left more than one layer lower than any other part of the embankment width, in case at least two carriageways are being constructed at the same time.

Shoulder construction shall be brought up simultaneously with the pavement

construction.

During construction, the roadway shall be kept in shape and drained out at all times. When unsuitable material has been placed in the embankment by the Contractor, he shall remove it without extra payment.

The fill behind abutment and wing walls of all bridges, pipes, slabs and box culverts shall be deposited in well-compacted, horizontal layers not exceeding twenty (20) cm in thickness to the density 100 percent of maximum dry density as per AASHTO T-180 (D).

9.3.7 Trial Sections

Before stating the formation of the embankment, the Contractor shall construct a trial sections of 200 metres, for each soil type proposed to be used for compaction as directed by the Engineer. The soils used in the trials shall be the same as those intended to be used for the formation of embankments and the compacting equipment shall be same equipment that Contractor will use during compaction of embankment and that has been accepted by the Engineer.

The objective of these trials will be to determine the suitable moisture contents and the relation between the number of passes of compacting equipment and density obtained for particular type of soil. No separate payment will be made for this work, which will be required as a subsidiary obligation of the Contract under pay items as included in SECTION-9.5, as the case may be. If the trial sections are carried out in the permanent work and approved by the Engineer, the lengths of the trials should be deducted from the cost of respective permanent works.

9.4 SAMPLING AND TESTING REQUIREMENT

The sampling and testing requirement for granular sub-base shall be as included in Table 9.4.

Table 9.4, Sampling & Testing Requirement of Embankment

Sr. No.	Test	Designation	Frequency
1	Classification	AASHTO M-145	1 per 2000 cubic metre
2	CBR	AASHTO T-193	1 per 2000 metre
3	Swelling	AASHTO T-193	1 per 2000 cubic metre
4	Moisture (Lab) Density or Relative Density	AASHTO T-180 ASTM D-4254	1 per 2000 metre 1 per 1000 metre
5	Field Density	AASHTO T-191	1 per 200 metre

9.5 MEASUREMENT AND PAYMENT

9.5.1 Measurement

The quantities to be paid for shall be the number of cubic feet or cubic meters (whichever is included in Bill of Quantities) calculated in accordance with the designed lines and grades and the ground levels as established SECTION-2.9. The quantities to be paid shall have been compacted in place, accepted by the Engineer formed with material resulting from:

A) Formation of Embankment from Borrow Excavation

Measurement shall be made as under:

Formation from Borrow = Total Embankment Quantity (minus) suitable Roadway excavation Quantity (minus) suitable structural excavation Quantity.

B) Formation from structural Excavation

This quantity shall be the same as calculated for structural excavation irrespective of its haulage distance except that declared unsuitable by the Engineer.

C) Formation from Roadway Excavation

This quantity shall be the same as calculated for Roadway Excavation. The Contractor will be supposed to use material from Roadway Excavation irrespective of haulage distance. However, if Contractor, for his own convenience, uses the material from borrow, he can do it, but, without any extra cost to the Project.

In the measurement of "Formation of Embankment on steep slopes" no allowance will be made for the benching or volume of material cut out from the hill side or from the first half width fill to accommodate the compacting equipment but will be calculated only on the net volume of fill placed against the original hill sides, the old embankment or the first half width fill.

9.5.2 Payment

A) Formation from Borrow Excavation

The quantity to be paid for shall be the number of cubic feet or cubic meters (whichever is included in Bill of Quantities) placed in embankment, measured as provided above for material from borrow excavation and such a payment will be deemed to include cost of excavation, payment of royalty, levies and taxes of Local, Provincial and Federal Government, cost of hauling including all lead and lift, spreading, watering, rolling, labour, equipment, tools and incidental necessary to complete this item.

B) Formation from Structural Excavation

The quantity to be paid for shall be the number of cubic feet or cubic meters (whichever is included in Bill of Quantities) placed in embankment and measured as provided above for material from structural excavation and such payment will be deemed to include cost of excavation, hauling, dumping, spreading, watering, rolling, labour, equipment, tools and incidental necessary to complete this item.

C) Formation from Roadway Excavation

The quantity to be paid for shall be the number of cubic feet or cubic meters (whichever is included in Bill of Quantities) placed in embankment and measured as provided above for material from roadway excavation and such payment will be deemed to include cost of excavation, hauling, dumping, spreading, watering, rolling, labour, equipment, tools and incidental necessary to complete this item.

SECTION - 10: SUBGRADE PREPARATION

10.1 SCOPE OF WORK

The sub grade preparation shall be that part of the work on which, the sub base is placed or, in the absence of sub base, act as the base of the pavement structure. It shall extend to the full width of the road bed including the shoulders and laybys as indicated on the Drawings or as specified herein.

10.2 CONSTRUCTION REQUIREMENT

10.2.1 Prior Work

Before commencing the work all culverts, drains, ditches including fully compacted backfill over them outlets for drainage, head walls/wing walls of culverts and any other minor structure below thirty (30) centimetres of existing sub grade level or all structures which will be below thirty (30) centimetres of newly placed sub grade level, shall be in such operative conditions as to ensure prompt and effective drainage and to avoid damage to sub grade by surface water. No work of sub grade preparation will be started before the prior work herein described have been approved by the Engineer.

10.2.2 Compaction Requirement

All materials down to a depth of 30 cm below the sub grade level in earth cut or embankment shall be compacted to at least 95 percent of the maximum dry density as determined according to AASHTO T-180 Method 'B' or 'D' whichever is applicable, or corresponding Relative Density as per ATM D-4254-83.

10.2.3 Sub-grade Preparation in Earth Cut

In case bottom of sub grade level is within thirty (30) cm of the natural ground, the natural ground surface shall be scarified, broken up, adjusted to moisture content and compacted to minimum density of ninety-five (95) percent of the maximum dry density as determined by AASHTO T-180 Method D. Subsequent layer of approved material shall be incorporated to ensure that the depth of sub grade layer is thirty (30) cm.

In case, the bottom of sub grade is below the natural ground by more than thirty (30) cm, the material above the top of sub grade shall be removed and subsequent layer of thirty (30) cm shall be scarified, broken up, adjusted to moisture content and compacted to the same degree of compaction as described above.

In case, unsuitable material is encountered at the sub grade level within a depth of thirty (30) cm, the same shall be removed in total and replaced by the approved material. The Contractor shall be paid for removal of

unsuitable material as per Section - 7: and for replacement of approved material, the payment will be made under pay item included in Section - 9:.

10.2.4 Sub grade Preparation in Rock Cut

Excavation in rock shall extend to the sub grade level as shown on Drawings. Rock shall be undercut nearly to required elevation and sections shown on the Drawings or as directed by the Engineer. Transverse and longitudinal profiles checked by template shall be accurate to the requirement. Cuts below sub grade level shall be backfilled with selected sub base material and compacted to minimum ninety-eight (98) percent of the maximum dry density as determined by AASHTO T-180, method 'D'. No compensation shall be made to the Contractor for over-cut or remedial measures as described above.

No rock shall be higher than two (2) centimetres above the undercut section elevation. The undercut material shall be placed in embankment or disposed of at the direction of Engineer.

10.2.5 Sub-grade in Embankment

When the sub grade is formed in embankment, its width shall be the full width of top of embankment and material placed in the upper part of embankment down to a depth of thirty (30) centimetres below sub grade level shall meet compaction requirement of SECTION-10.2.2. Soils having a minimum value of CBR as shown on the Drawings and determined at 95% compaction with a swell value of not more than 0.3 percent shall be used. Unsuitable material if encountered within the existing formation layer as per laboratory specified test, shall be removed, disposed of and replaced by suitable one as per direction of the Engineer of which the payment will be made under relevant items of work.

Rollers and other equipment of approved size and type, accepted by the Engineer, shall be used for compaction. Water shall be added to obtain optimum moisture content; if necessary. Contractor shall ensure proper compaction in restricted areas by use of special equipment and rollers. No compensation shall be made for extra work due to restricted space.

Performance of this item of work shall not be paid for under this section but shall be deemed to be covered by the contract price for pay item under Section - 9:, FORMATION FOR EMBANKMENT.

10.2.6 Sub-grade Level in Existing Road

Where indicated on the Drawings or directed by the Engineer that the existing road surface is to be used as the sub-grade, the correct elevation on which the base or sub-base is to be laid shall be obtained, where necessary, either by means of levelling course or by excavation. The levelling course shall be constructed to the requirements of the Engineer and paid for under the

appropriate Pay Item involved. Excavation shall include disposal of any surplus material in the adjacent embankment or elsewhere as directed by the Engineer.

In case, the design level of sub-grade is within 30 cm of the existing ground/road then the item shall be measured and paid accordingly.

10.2.7 Sub-grade reinforcement

When the width of the existing pavement, either to be scarified or not, is insufficient to contain the sub-base or base to be placed upon it, the Engineer may order to strengthen and support the sub-base or base on one or both sides of the existing pavement. This work shall consist of the removal and disposal of any unsuitable material and its replacements with suitable material to such width and depth as required by the Engineer.

The excavated material shall, if declared suitable for use elsewhere in the embankment by the Engineer be so used, and payment for its removal shall be covered under the contract price of pay item under Section - 9;; if declared unsuitable it shall be disposed of and paid as provided in Section - 7:.. The finished compacted surface of the sub-grade shall be as specified in SECTION-10.2.3.

10.2.8 Protection of Completed Work

Any part of the sub-grade that has been completed shall be protected and kept well drained. Any damage resulting from carelessness of the Contractor shall be repaired as directed by the Engineer without additional payment.

The Contractor shall be responsible for all the consequences of traffic being admitted to the sub-grade. He shall repair any ruts or ridges occasioned by his own traffic or that of others by reshaping and compacting with rollers of the size and type necessary for such repair. He shall limit the area of sub-grade preparation to an area easily maintained with the equipment available. Sub-grade preparation and sub-base or base placing shall be arranged to follow each other closely. The sub-grade, when prepared too soon in relation to the placing of the sub-base, is liable to deteriorate, and in such case the Contractor shall, without additional payment, repair, reroll, or re-compact the sub-grade as may be necessary to restore it to the state specified herein.

10.2.9 Templates and Straightedges

The Contractor shall provide for the use of the Engineer, satisfactory templates and straightedges in sufficient numbers to check the accuracy of the work, as provided in these specifications and no subsequent work shall be permitted until the sub-grade levels have been checked and approved by the Engineer. The allowable tolerances are included in Table 10.1.

Table 10.1, Allowable Tolerances for Sub-Grade

Sr. No.	Description	Range, mm
1	Thickness	± 20
2	Level	+0 and -40
3	5-metre Straight Edge	30
4	Cross Fall	± 0.50
5	Longitudinal Grade in 30-metre	± 0.10

10.3 SAMPLING AND TESTING REQUIREMENT

The sampling and testing requirement for granular sub-base shall be as included in Table 10.2.

Table 10.2, Sampling & Testing Requirement of Sub-Grade

Sr. No.	Test	Designation	Frequency
1	Classification	AASHTO M-145	1 per 2000 cubic metre
2	Moisture (Lab) Density or Relative Density	AASHTO T-180 ASTM D-4254	1 per 2000 metre 1 per 1000 metre
3	Field Density	AASHTO T-191	1 per 200 metre

10.4 MEASUREMENT AND PAYMENT

10.4.1 Measurement

The quantity to be paid for shall be the number of square feet or square meters (whichever is included in Bill of Quantities) of sub-grade prepared and accepted. Sub-grade in rock cuts and on embankment not consisting of the existing road surface in fill area-shall not be measured for direct payment.

Sub-grade preparation on "Existing Surface" shall only be measured for payment when ordered by the Engineer.

10.4.2 Payment

The quantities, determined as provided above, shall be paid for at the contract unit price of square feet or square meters (whichever is included in Bill of Quantities) and payment shall be full compensation for furnishing of material, water, equipment, tools, labour, and all other items necessary for completion of work.

PART - 3: SUBBASE & BASE FOR ROADS

SECTION - 11: GENERAL

11.1 DESCRIPTION

The work shall consist of furnishing, spreading, and compacting graded crushed aggregate subbase course, crushed aggregate base course, asphaltic base course, crushed limestone base course, cement stabilized subbase and base course, lime stabilized subbase and bitumen stabilized subbase and base, crack relief layers, constructed on a prepared bed and all incidentals in accordance with these specification in conformity with the lines, grade thickness and typical cross-section shown on the drawing and/or as directed by the Engineer.

11.2 MATERIAL

The material shall consist of sand, gravel or a sand gravel mixture obtained from the source approved by the Engineer. Material requirements for this work are specified under various items of the section.

11.2.1 Sampling and Testing

Adequate representative samples shall be submitted to Engineer for testing and preliminary approval not less than twenty days, before the intended material is to be used in the work. The material, when deemed necessary by the Engineer, shall be sampled and tested in his presence by the Contractor for particular subbase, base course as called for in the specification of particular application and /or the bill of quantities, and/or as shown on the drawing, to assure conformance with the requirements of specification. Any material found not to conform with the requirements will be subject to rejection. All rejected material shall be removed and replaced with the material meeting the requirement, at no additional cost to the Employer.

Preliminary approval of source shall not mean that all the material in the source is approved.

Sampling and testing, unless otherwise stated, shall be according to the standard methods prescribed in the latest edition of the American Association of State Highway and Transportation Officials (AASHTO) or standard specification and methods of sampling and testing, provided in latest version of American Society of Testing and Materials (ASTM) or, for particular materials or procedures, the British Standards Institution. Any deviation from the methods and procedure prescribed therein may be made only as directed in writing by the Engineer as per relevant "Table for Sampling and Testing Frequency".

11.2.2 Selection of Place for Sampling

The selection of representative samples for testing shall be by "Random

Sampling Method" by which every part of a lot or stockpile has equal chance to be selected. When it is necessary to sample stockpiles, every effort should be made to enlist the service of power equipment that is capable of exposing the material at various levels and locations. In sampling sand from stockpiles, the outer layer which may have become dry, causing segregation shall be removed and representative samples of the damp sand selected.

11.2.3 Number and Size of Samples

The number and size of sample required depends on the intended use of the material, the quantity of material involved and the variation both in quality and size of aggregate. A sufficient number of samples shall be obtained to cover all variations in the material. The quantities must be sufficient to provide for proper execution of the required tests.

11.2.4 Schedule for Sampling and Testing

The sampling frequency, acceptance limits, and other information for proper control of each work shall be as given in tables for Sampling and Testing Requirements which will provide the minimum testing frequency under normal conditions. Where sampling frequencies are not given in the table, they shall be as directed by the Engineer. Where frequencies are given as per layer or per strip, this will mean the width of strip or layer being laid at any one item. if the materials or operations are variable and good, control is difficult to maintain, greater sampling frequency may be taken as directed by the Engineer.

11.2.5 Tolerances

The allowable tolerances for the subgrade prior to placing the overlying courses, together with the allowable tolerances for the subbase and base are as specified in tables for Allowable Tolerances, in these specifications.

11.3 PLANT & EQUIPMENT

All equipment, tools and machines used in the performance of work shall be maintained in satisfactory conditions at all times and be subject to the approval of the Engineer. List of recommended type of equipment is only for guidance of Contractor. However, Contractor will be responsible to give required quality and workmanship through any type of equipment irrespective of any approval given by the Engineer.

11.4 TRIAL STRIPS

Contractor shall prepare trial strip for any item as appearing in this chapter, to establish the following.

- a. Maximum thickness of loose layer, which can be laid.
- b. Type of equipment to be used.

-
- c. Watering and mixing procedures.
 - d. Number of passes required to satisfactorily compact the layer to level.
 - e. Any other requirement ordered by the Engineer.

Engineer shall then inspect and test the Trial Strip and approve the procedure in writing, to carry out the work. However, this approval shall not relieve the Contractor from his contractual obligation.

SECTION - 12: GRANULAR SUB-BASE

12.1 SCOPE OF WORK

This item shall consist of furnishing, spreading in one or more layers and compacting granular subbase according to the specifications and Drawings and/or as directed by the Engineer.

12.2 MATERIAL REQUIREMENTS

Granular subbase material shall consist of natural or processed aggregates such as gravel, sand or stone fragment and shall be clean and free from dirt, organic matter and other deleterious substances, and shall be of such nature that it can be compacted readily under watering and rolling to form a, firm, stable subbase.

The material shall comply to the following grading and quality requirements:

- a) The subbase material shall have a gradation curve within the limits for grading as included in Table 12.1.

Table 12.1, Gradating Requirements for Granular Subbase Material

Sr. No.	Sieve Designation		Mass Percent Passing
	mm	inch	
1	60.0	2-1/2	-
2	50.0	2	100
3	25.0	1	55-85
4	9.5	3/8	40-70
5	4.75	No.4	30-60
6	2.0	No.10	20-50
7	0.425	No.40	10-30
9	0.075	No.100	5-15

The Coefficient of Uniformity D_{60}/D_{10} shall be not less than 3, where D_{60} and D_{10} are the particle diameters corresponding to 60% and 10%, respectively, passing (by weight) in a grain size analysis, curve.

- a. The Material shall have a CBR value of at least 50% at 100% maximum dry density, determined according to AASHTO T-193. The CBR value shall be obtained at a density corresponding to Ninety-eight (98) percent of the maximum dry density determined according to AASHTO T-180 Method-D.
- b. The coarse aggregate material retained on sieve No. 4 shall have a percentage of wear by the Los Angeles Abrasion (AASHTO T-96) of not more than fifty (50) percent.

- c. In order to avoid intrusion of silty and clayey material from the subgrade in the subbase, the ratio D15 (Subbase) D85 (Subgrade) should be less than 5.

Where D85 and D15 are the particle diameters corresponding to eighty-five (85) % and fifteen (15) %, respectively, passing (by weight) in a grain size analysis, curve.

- d. The fraction passing the 0.075 mm (No. 200) sieve shall not be greater than two third of the fraction passing the 0.425 mm (No. 40) sieve. The fraction passing the 0.425 mm sieve shall have a liquid limit of not greater than 25 and a plasticity index of 6 or less.
- e. If over-size is encountered, screening of material at source shall invariably be done, no hand picking shall be allowed, and however hand picking may be allowed by the Engineer, if over-size quantity is less than 5% of the total mass.
- f. Sand equivalent for all classes shall be 25 min.

12.3 CONSTRUCTION REQUIREMENTS

12.3.1 Spreading

Granular subbase shall be spread on approved subgrade layer as a uniform mixture. Segregation shall be avoided during spreading and the final compacted layer shall be free from concentration of coarse or fine materials.

Granular subbase shall be deposited on the roadbed or shoulders in a quantity, which will provide the required compacted thickness without resorting to spotting, picking up or otherwise shifting the subbase material. In case any material is to be added to compensate for levels, the same shall be done after scarifying the existing material, to ensure proper bonding of additional material.

When the required thickness is fifteen (15) cm or less, the aggregates may be spread and compacted as one layer, but in no case shall a layer be less than seven and one half (7.5) centimetres thick. Where the required thickness is more than 15 cm, the aggregates shall be spread and compacted in 2 or more layers of approximately equal thickness, but in any case, the maximum compacted thickness of one layer shall not exceed 15 cm. All subsequent layers shall be spread and compacted in a similar manner.

The maximum compacted thickness of one layer shall not exceed 15 cm. All subsequent layers shall be spread and compacted in a similar manner.

The granular subbase shall be spread with equipment that will provide a uniform layer conforming to the specified item both transversely and longitudinally within the tolerances as specified in these specifications. No hauling or placement of material will be permitted when in the judgment of

the Engineer, the weather or road conditions are such that the hauling operation will cause cutting or rutting of subgrade or contamination of sub base material.

12.3.2 Compaction Trials

Prior to commencement of granular subbase operation, Contractor shall construct a trial length, not to exceed, five hundred (500) meters and not less than two hundred (200) meters with the approved subbase material as will be used during construction to determine the adequacy of the Contractor's equipment, loose depth measurement necessary to result in the specified compacted layer depths, the field moisture content and the relationship between the number of compaction passes and the resulting density of the material.

12.3.3 Compaction

The moisture content of subbase material shall be adjusted prior to compaction by watering with approved sprinklers mounted on trucks or by carrying out, as required, in order to obtain the specified compaction.

The subbase material shall be compacted by mean of approved vibrating rollers or steel or steel wheel rollers (rubber-tired rollers may be used as a supplement), progressing gradually from the outside towards the centre, except on Super elevated curves, where the rolling shall begin at the low side end progress to the high side. Each succeeding pass shall overlap the previous pass by at least one third of the roller width. While the rolling progresses, the entire surface of each layer shall be properly and pressed with a motor grader, to attain a smooth surface free from ruts or ridges and having proper section and crown. Rolling shall continue until entire thickness of each layer is thoroughly and uniformly compacted to the specified density.

Any area inaccessible to rolling equipment shall be compacted by means of hand-guided rollers, plate compactors or mechanical tampers, where the thickness in loose layer shall not be more than 10 cm.

If the layer of subbase material, or part thereof does not fulfil the required finish, the Contractor shall at his own expense, rework, work and re-compact the material before succeeding layer of the pavement schedule to construct.

Immediately prior to the placing of first layer of base course the subbase layer (both under the travelled way and the shoulders) shall conform to the required level and shape. Prior to placing the succeeding layers of the material, the top surface of each layer shall be made sufficiently moist to ensure bond between the layers. The edges or edge slopes shall be planed or otherwise dressed to conform to the lines and dimensions shown on the Drawings.

No material for construction of base shall be placed until the subbase has been approved by the Engineer.

12.3.4 Compacting requirements

The relative compaction of each layer of the compacted subbase shall not be less than hundred (100) percent of the minimum dry density determined according to AASHTO T-180 Method D. The field density shall be determined according to AASHTO T-191 or other approved method. For all materials, the field density thus obtained shall be adjusted to accurate for oversize particles (retained on 19 mm sieve) as directed by the Engineer. Also, for adjustment of any material retained on 4.75 mm sieve, AASHTO Method T-224 shall be used.

12.3.5 Moisture Content Determination

As it is customary in the project laboratories that small samples of materials are placed in ovens for moisture determination for proctor, following precautions are necessary to ensure proper compaction results:

- Same size of sample is placed in oven for moisture determination in case of laboratory density (Proctor) and field density.
- Moisture content for calculation of field density and proctor shall be observed on material passing 4.75 mm sieve.

12.3.6 Tolerance

The subbase shall be compacted to the desired level and cross slopes as shown on the Drawings. The allowable tolerances shall be according to limits as included in Table 12.2.

Table 12.2, Allowable Tolerances for Sub-Base

Sr. No.	Description	Range, mm
1	Thickness	+10 and -20
2	Level	+0 and -25
3	5-metre Straight Edge	20
4	Cross Fall	± 0.30
5	Longitudinal Grade in 30-metre	± 0.10

12.4 SAMPLING AND TESTING REQUIREMENT

The sampling and testing requirement for granular sub-base shall be as included in Table 12.3.

Table 12.3, Sampling & Testing Requirement of Granular Sub-Base

Sr. No.	Test	Designation	Frequency
1	Gradation	AASHTO T-27	3 per source and 1 per 1000 cubic metre
2	Plasticity Index	AASHTO T-89 & T-90	3 per source and as required based on visual observation
3	CBR	AASHTO T-193	3 per source and as required based on variation in gradation or 1 per 1000 cubic metre
4	Abrasion	AASHTO T-96	3 per source and 1 per 500 cubic metre
5	Moisture Density	AASHTO T-180	1 per 1000 cubic metre
6	Field Density	AASHTO T-191 & T-238 & T-239	4 per layer per 400 metre laid or 3 minimum per layer, if less than 400 meters laid
7	Sand Equivalent	AASHTO T-176	3 per source and as required based on visual observation

12.5 MEASUREMENT AND PAYMENT

12.5.1 Measurement

The quantity of subbase to be paid for shall be measured in cubic foot or cubic metre (whichever is included in Bill of Quantities) by the theoretical volume in place as shown on the Drawings or as directed and approved for construction by the Engineer, placed and accepted in the completed granular subbase course. No allowance will be given for material placed measure the theoretical limits as shown on the drawing sections.

12.5.2 Payment

The accepted quantities measured as provided above shall be paid for at the contract unit price per cubic foot or cubic metre (whichever is included in Bill of Quantities) of granular subbase, which price and payment shall constitute full compensation for furnishing all materials, hauling, placing, watering, rolling, labour, equipment, tools and incidentals necessary to complete the item.

SECTION - 13: AGGREGATE BASE COURSE

13.1 SCOPE OF WORK

This item shall consist of furnishing, spreading and compacting one (1) or more layers of crushed aggregate base course on a prepared subgrade, subbase, or existing road surface, in accordance with the specifications and the Drawings and/or as directed by the Engineer.

13.2 MATERIAL REQUIREMENTS

13.2.1 Aggregate Base

Material for crushed aggregate base course shall consist of crushed hard durable gravel, rock or stone fragments. It shall be clean and free from organic matters, lumps of clay and other deleterious substances. The material shall be of such a nature that it can be compacted readily under watering and rolling to form a firm, stable base for both flexible and rigid pavements.

The aggregate base shall comply to the following grading and quality requirements:

- a. The gradation curve of the material shall be smooth and within the envelope limits for grading as given below in Table 13.1.

Table 13.1, Grading Requirements for Aggregate Base Material

Sr. No.	Sieve Designation		Mass Percent Passing
	mm	inch	
1	50.0	2	100
2	25.0	1	70-95
3	9.5	3/8	40-75
4	4.75	No.4	30-60
5	2.0	No.10	20-50
6	0.425	No.40	12-25
7	0.075	No.200	5-10

The material shall be well graded such that the coefficient of Uniformity D_{60}/D_{10} shall be greater than four (4).

- b. Crushed Aggregate (material retained on sieve No.4) shall consist of material of which at least ninety (90) percent by weight shall be crushed particles, having a minimum of two (2) fractured faces.
- c. The Coarse aggregate shall have a percentage of wear by the Loss Angeles Abrasion test (AASHTO T-96) of not more than forty (40)
- d. The material shall have a loss of less than twelve (12) percent when subjected to five cycles of the Sodium Sulphate Soundness test

according to AASHTO T-104.

- e. The sand equivalent determined according to AASHTO T-176 shall not be less than 45 and the material and the portion of filler and binder, including any blended material, passing No.40 mesh sieve) shall have a liquid limit of not more than twenty-five (25) and a plasticity Index of not more than 3 as determined by AASHTO T-89 and T-90.
- f. The material passing the 19 mm sieve shall have a CBR value of minimum eighty (80) percent, tested according to the AASHTO T 193. The CBR value shall be obtained at the maximum dry density determined according to AASHTO T 180, Method D.
- g. Laminated material shall not exceed 15% of total volume of Aggregate Base Course.

13.2.2 Filler for Blending

If filler, in addition to that naturally present in the aggregate base material is necessary for meeting the grading requirement or for satisfactory bonding of the material. It shall be uniformly blended with the base course material at the crushing plant or in a pug mill unless otherwise approved. The material for such purpose shall be obtained from sources approved by the Engineer. The material shall be free from organic matter, dirt, shale, clay and clay lump or other deleterious matter and shall conform to following requirement.

13.3 CONSTRUCTION REQUIREMENTS

13.3.1 Preparation of Surface for Crushed Aggregate Base Course

In case crushed aggregate base is to be laid over prepared sub base course, the subbase course shall not have loose material moisture in excess to optimum moisture content Spreading shall conform in all respects to the requirements specified under this heading in SECTION-12.3.1.

It shall be mandatory upon the Contractor to lay the aggregate base course in specified thickness, line and grade on approved surface using mechanical paver. The paver shall be power propelled unit, provided with automatically controlled screeds and feed controls capable of spreading the aggregates and maintaining specified thickness and grade. The paver shall be equipped with receiving hoppers having sufficient capacity for a uniform spreading operation. The paver shall be operated at a speed to give best results. The mechanical paving machine has to be approved by the Engineer prior to start of spreading activity.

13.3.2 Compaction

Compaction process shall conform in all respect to the requirements specified under this heading in SECTION-12.3.3.

13.3.3 Compaction Requirement

The relative compaction of each layer of the compacted base shall not be less than 100 percent to the maximum dry density determined according to AASHTO T-180, Method D (Modified). Tide field density shall be determined according to AASHTO T-191 or other approved method. For all materials, the field density thus obtained shall be adjusted to account for oversize particles (retained on 19 mm sieve) as directed by the Engineer. Also, for adjustment of any material retained on 4.75 mm sieve, AASHTO Method T-224 shall be used.

Completed base course shall be maintained in an acceptable condition at all times until prime coat is applied. When base course is to carry traffic for an indefinite length of time before receiving surfacing, the Contractor shall maintain the surface until final acceptance and shall prevent revelling by wetting, blading, rolling and addition of fines as may be required to keep the base tightly bound and leave a slight excess of material over the entire Surface which must be removed and the surface finish restored before application of prime coat.

13.3.4 Moisture Content Determination

Moisture content determination shall conform in all respects to the requirements specified under SECTION-12.3.5, GRANULAR SUB-BASE.

13.3.5 Trial Sections

Prior to commencement of aggregate base course operations, a trial section of two hundred (200) meters minimum, but not to exceed five hundred (500) meters shall be prepared by the Contractor using same material and equipment as will be used at site to determine the adequacy of equipment, loose depth measurement necessary to result in the specified compacted layer depths, field moisture content, and relationship between the number of compaction passes and the resulting density or material.

13.3.6 Tolerance

The completed base course shall be tested for required thickness and smoothness before acceptance. Any area having waves, irregularities in excess of one (1) cm in three (3) m or two (2) cm in fifteen (15) m shall be corrected by scarifying the surface, adding approved material, reshaping re-compacting and finishing as specified. Skin patching of an area without scarifying the surface to permit proper bonding of added material shall not be permitted. The allowable tolerances shall be according to limits as included in Table 13.2.

Table 13.2, Allowable Tolerances for Base

Sr. No.	Description	Range, mm
1	Thickness	+5 and -10
2	Level	+5 and -10
3	5-metre Straight Edge	6
4	Cross Fall	± 0.20
5	Longitudinal Grade in 30-metre	± 0.10

13.3.7 Acceptance, Sampling and Testing

Acceptance of sampling and testing with respect to materials and construction requirements shall be governed by the Table 13.3 or as approved by the Engineer.

13.4 SAMPLING AND TESTING REQUIREMENT

The sampling and testing requirement for aggregate base shall be as included in Table 13.3.

Table 13.3, Sampling & Testing Requirement of Aggregate Base

Sr. No.	Test	Designation	Frequency
1	Gradation	AASHTO T-27	3 per source and 1 per 1000 cubic metre
2	Plasticity Index	AASHTO T-89 & T-90	3 per source and as required based on visual observation
3	CBR	AASHTO T-193	3 per source and as required based on variation in gradation or 1 per 1000 cubic metre
4	Abrasion	AASHTO T-96	3 per source and 1 per 5000 cubic metre
5	Sodium Sulphate Soundness	AASHTO T-104	3 per source and 1 per 5000 cubic metre
6	Fractured Faces	Visual	3 per source and as required based on visual observation
7	Moisture Density	AASHTO T-180	1 per 1000 cubic metre
8	Field Density	AASHTO T-191, T-238 & T-239	4 per layer per 400 metre laid or 3 minimum per layer, if less

Sr. No.	Test	Designation	Frequency
			than 400 meters laid
9	Sand Equivalent	AASHTO T-176	3 per source and as required based on visual observation

13.5 MEASUREMENT AND PAYMENT

13.5.1 Measurement

The quantity of aggregate base to be paid for shall be measured in cubic foot or cubic metre (whichever is included in Bill of Quantities) by the theoretical volume in place as shown on the Drawings or as directed and approved for construction by the Engineer, placed and accepted in the completed crushed aggregate base course. No allowance will be given for materials placed outside the theoretical limits as shown on the cross sections.

13.5.2 Payment

The accepted quantities measured as above shall be paid for at the contract unit price per cubic foot or cubic metre (whichever is included in Bill of Quantities) of aggregate base, which price and payment shall constitute full compensation for furnishing all materials, hauling, placing, watering, rolling, labour, equipment, tools and incidentals necessary to complete this item.

SECTION - 14: ASPHALTIC BASE COURSE (PLANT MIX)

14.1 SCOPE OF WORK

This work shall consist of furnishing of plant, labour, equipment and material and performing all operations in connection with the construction of an asphaltic plant-mix base course on a previously constructed and accepted subgrade, subbase or base course, subject to terms and conditions of the Contract, and in strict accordance with this Section of the Specification, the Drawings and the directions of the Engineer.

14.2 MATERIAL REQUIREMENTS

14.2.1 Mineral Aggregate

Mineral aggregate for bituminous base course shall consist of coarse aggregate, fine aggregate and filler material, if required, all conforming with the following requirements:

Coarse aggregate, which is the material, retained on AASHTO No. 4 sieve shall consist of crushed rock, crushed gravel or crushed boulder. It shall be clean, hard, tough, sound, durable, free from decomposed stones, organic matter, shale, clay lump or other deleterious substances. Rock or boulders from which coarse aggregate is obtained, shall be of uniform quality throughout the quarry.

The crushing shall be so regulated that at least ninety-five (95) percent by weight of material retained on AASHTO No. 4 sieve shall consist of pieces with at least two (2) mechanically fractured faces, and when tested for stability of bituminous mix shall show satisfactory stability.

Fine aggregate, which is material passing No. 4 sieve, shall consist of 100% crushed material from rock or boulder. No natural sand will be allowed in the mix.

When the combined grading of the coarse and fine aggregates is deficient in material passing No. 200 sieve, additional filler material shall be added. The filler material shall consist of finely divided rock dust, hydrated lime, hydraulic cement or other suitable mineral matter. However, in case the coarse aggregates are of quartzite nature, then hydrated lime or a better material shall be allowed. At the time of use, it shall be sufficiently dry to flow freely. Filler material shall conform to gradation as included in Table 14.1.

Table 14.1, Gradation for Filler Material

Sr. No.	US Standard Sieve	Percent Passing by Weight
1	No.30	100
2	No.50	95-100
3	No.200	70-100

The coarse and fine aggregates shall meet the following requirements:

- a. The percentage of wear by the Los Angeles Abrasion test (AASHTO T 96) shall not be more than forty (40);
- b. The loss when subject to five cycles of the sodium sulphate Soundness test (AASHTO T 104) shall be less than twelve (12) percent;
- c. The Sand Equivalent (AASHTO T 123) determined after oil processing except for addition of asphalt cement shall not be less than forty-five (45);
- d. Fine aggregates shall have a liquid limit not more than twenty-five (25) and a Plasticity Index of not more than six (6) as determined by AASHTO T 89 and T-90;
- e. The portion of aggregate retained on the 9.5 mm (3/8 inch) sieve shall not contain more than 15 percent by weight of flat and/or elongated particles (ratio of maximum to minimum dimensions is 2:5:1);
- f. Stripping test shall be performed on coarse aggregates as described under AASHTO T-182 and only that material shall be allowed which qualifies the test;
- g. The coarse aggregates shall be checked if desired by the Engineer for cationic and anionic behaviour so that their affinity with the bitumen to be used is verified; and
- h. Petrographic examination of the coarse aggregates conducted if so, directed by the Engineer.

14.2.2 Asphaltic Material

Asphalt binder to be mixed with the aggregate to produce asphaltic base shall be asphalt cement having penetration grade 60-70, as specified by the Engineer. Generally, it will meet the requirements of AASHTO M-20.

14.2.3 Asphalt Concrete Base Course Mixture

The composition of the asphaltic concrete paving mixtures for base course shall conform to requirements as included in Table 14.2.

Table 14.2, Combined Aggregate Grading Requirements

Sr. No.	US Standard Sieve Size	Percent Passing by Weight
1	2" (50mm)	-
2	1-1/2" (38mm)	100
3	1" (25mm)	75-90
4	3/4" (19mm)	65-80
5	1/2" (12.5mm)	55-70
6	3/8" (9.5mm)	45-60

Sr. No.	US Standard Sieve Size	Percent Passing by Weight
7	No.4 (4.75mm)	30-45
8	No.8 (2.38mm)	15-35
9	No.50 (0.30mm)	5-15
10	No.200 (0.075mm)	2-7
11	Asphalt Content Weight, %age of total mix	3 (minimum)

The asphalt concrete levelling / base course mixture shall meet the following Marshall Test Criteria as included Table 14.3.

Table 14.3, Marshall Test Criteria for Asphaltic Base Course

Sr. No.	US Standard Sieve	Percent Passing by Weight
1	Compaction, number of blows each end of specimen	75
2	Stability	1000 kg (min.)
3	Flow, 0.25 mm (0.01-inch)	8-14
4	Percent air voids in mix	4-8
5	Percent voids in mineral aggregates	According to Table 5.3 MS-2, Asphalt institute, sixth edition 1993
6	Loss in Stability	25 percent (Max.)

Mixes composed of larger size aggregates with maximum size up to 38 mm (1.5 inches) will be prepared according to modified Marshall method as per MS-2 Asphalt institute, sixth edition, 1993 or the latest edition. The procedure is basically the same as the original method except for following differences that are due to the larger specimen size that is used:

- The hammer weighs 10.2 kg (22.5 lb) and has a 149.4 mm (5.88 inches) flat tamping face. Only mechanically-operated device is used for the same 457 mm (18 inches) drop height.
- The specimen has a 152.4 mm (6 inches) diameter by 95.2 mm (3.75 inches) height.
- The batch weights are typically of 4 Kg.
- The equipment for compacting and testing (moulds and breaking heads) are proportionately larger to accommodate the larger specimens.
- The mix is placed in the mould in two approximately equal increments, with spading performed after each increment to avoid honey-combing.
- The number of blows needed for the larger specimen is 1.5 times (75 or 112 blows) of that required for the smaller specimen (50 or 75

blows) to obtain equivalent compacting.

- g. The design criteria shall be modified as well, the minimum stability shall be 2.25 times and the range of flow values shall be 1.5 times normalized specimens.
- h. Similar to the normal procedure, following values, as included in Table 14.4, shall be used to convert the measured stability values to an equivalent value for a specimen with a 95.2 mm (3.75 inches) thickness, if the actual thickness varies.

Table 14.4, Correlation Values of Marshall Test Specimen

Sr. No.	Approximate Height, mm (Inch)	Specimen Volume, cubic cm	Correlation
1	88.9 (3-1/2)	1608 to 1626	1.12
2	90.5 (3-9/16)	1637 to 1665	1.09
3	92.1 (3-5/8)	1666 to 1694	1.06
4	93.7 (3-11/16)	1695 to 1723	1.03
5	95.2 (3-3/4)	1724 to 1752	1.00
6	96.8 (3-13/16)	1753 to 1781	0.97
7	98.4 (3-7/8)	1782 to 1810	0.95
8	100.0 (3-15/16)	1811 to 1839	0.92
9	101.6 (4)	1840 to 1968	0.90

14.2.4 Job-Mix Formula

At least one (1) week prior to production, a Job-Mix Formula (JMF) for the asphaltic base course to be used for the project, shall be established jointly by the Engineer and the Contractor in the project laboratory. Job mix formula shall combine the mineral aggregates and asphalts in such proportion conforming to specification requirements.

The JMF shall be established by Marshall Method of Mix Design according to the procedure prescribed in the Asphalt Institute Manual Series No. 2 (MS-2), sixth edition 1993, or the latest Edition.

The JMF, with the allowable tolerances shall be within the range specified in SECTION-14.2.3. Each JMF shall indicate a single percentage of aggregate passing each required sieve size and a single percentage of bitumen to be added to the aggregate.

The combined gradation should produce a smooth curve approximately paralleling grading band limits for designated mix. The JMF with allowable tolerances for a single test then become the job control grading band. If application of job-mix tolerances results in a job control grading band outside the master grading band, the full tolerances shall still apply.

Prior to final approval, the proposed job-mix, with a bitumen content at the permissible upper percentage limit determined in JMF, shall be compacted

to refusal (750 to 900 blows) and the resulting air voids in the mix shall not be less than 3%.

The ratio of wt. of filler (passing sieve No. 200) to that of asphalt shall range between 1-1.5 for hot climate areas with temperature more than 40°C.

After the JMF is established, all mixtures furnished for the project represented by samples taken from the asphalt plant during operation, shall conform thereto. Moreover, upon receiving the job-mix, approved by the Engineer, the Contractor shall adjust his plant to proportion the individual aggregates, mineral filler and asphalt to produce a final mix that, when compared to job mix formula shall be within the limits as included in Table 14.5.

Table 14.5, Adjustment of Plant based on Marshall Test

Sr. No.	Description	Range
1	Maximum Variation of Percentage of Materials	
	Retained No.4 and Larger	± 7.0%
	Passing No.4 to No.100 Sieve	± 4.0%
	Passing No.200	± 1.0%
2	Asphalt Content	
	Weight Percent of Total Mix	± 0.2%

In addition to meeting the requirements specified in the proceeding items, the mixture as established by the JMF shall also satisfy the following physical property:

Loss of Marshall stability by immersion of specimen in water at sixty (60) degree centigrade for 24 hours as compared with stability measured after immersion in water at 60 degrees centigrade for 20 minutes shall not exceeds twenty-five (25) percent. If the mixture fails to meet this criterion, JMF shall be modified or an anti-stripping agent shall be used.

Should a change of sources of materials be made, a new Job Mix Formula shall be established before the new material is used. When unsatisfactory results or other conditions make it necessary, a new Job Mix Formula will be required.

14.3 CONSTRUCTION REQUIREMENTS

14.3.1 Bituminous Mixing Plant

Plants used for the preparation of bituminous mixtures shall be "Batching Plants" conforming to AASHTO M 156, and of adequate capacity, coordinated and operated to produce a mixture within the limits of these specifications. Plant shall have minimum three cold bins and at least 3.5 decks of hot sieves.

14.3.2 Preparation of Aggregates

Before being fed to the dryer, aggregates for the asphaltic base courses shall be separated into three or more sizes and stored separately in cold bins. One bin shall contain aggregate of such size that eighty (80) percent will pass sieve No. 4, and the other two bins shall contain aggregate of such sizes that eighty (80) percent will be retained on sieve No. 4. Should fine material, be incorporated in the mix, separate bin shall be provided in addition to the three bins mentioned above. If filler is used as a separate component, it will also be stored and measured separately and accurately before being fed into the mixer through filler screw mechanism.

Asphalt cement shall be heated within a temperature range of hundred and thirty-five to hundred and sixty-three (135-163) degrees centigrade at the tune of mixing. Asphalt cement heated above maximum shown shall be considered overheated and shall be rejected and removed from job site.

Dried aggregate weighed and drawn to pug mill shall be combined with proportionate quantity of asphalt cement according to the job mix formula temperature of asphalt, expert for temporary fluctuations, shall not be lower than fifteen (15) degrees centigrade below the temperature of the aggregate, at the time, the two materials enter into the pug mill.

For placing the materials in bins or in moving them from bins to the dryer, any method, which causes segregation or uncontrolled combination of materials or different grading, shall be discontinued and the segregated or degraded materials shall be pre-screened for reuse.

Each aggregate ingredient shall be heated and dried at temperature not to exceed hundred and sixty-three (163) degrees centigrade. If aggregate contain sufficient moisture to cause foaming in the mixture or their temperature is in excess of hundred and sixty-three (163) degrees centigrade, they shall be removed from the bins and returned to their respective stock piles. In no case, shall be temperature of asphaltic mix exceed 163 degree centigrade when discharged from the pug mill.

Immediately after heating, the aggregates shall be screened to required sizes and stored in separate hot bins for batching and mixing with bituminous material.

Asphalt plant shall have minimum three and half (3 ½) sieve decks to effectively control the gradation of hot bins.

14.3.3 Hauling Equipment

Dump truck used for hauling bituminous mixtures shall have tight, clean, smooth metal beds, which have been thinly coated with an approved material to prevent adhering of material to the beds. Each truck shall have a cover of canvas or of other suitable material of sufficient size as to protect the mixture from the weather. The mixture will be delivered on the road at a temperature not less than hundred and thirty (130) degree C. Drivers of dump

trucks will ensure that while reversing the vehicles, paver is not pushed back producing a hump.

14.3.4 Bituminous Pavers

Bituminous pavers shall be self-contained, power-propelled units, provided with an automatically controlled activated screed or strike-off assembly, heated if necessary, capable of spreading and finishing courses of bituminous plant mix material in lane widths applicable to the specified and similar construction shall be capable of spreading and finishing course of bituminous plant mix material in widths shown on the Drawings.

The paver shall be equipped with a receiving hopper having sufficient capacity for a uniform spreading operation. The paver shall be equipped with automatic feed controls, properly adjusted to maintain a uniform depth of material ahead of the screed.

The screed or strike off assembly shall be capable of producing a finished surface of the required evenness and texture without tearing, shoving or gouging the mixture.

When laying the mixtures, the paver shall be capable of being operated at forward speeds consistent with satisfactory laying of the mixture. The paver shall be operated at speeds, which will give the best result for the type of power being used.

The mixed material shall be delivered to paver in time to permit completion of spreading, finishing and compaction of mixture during day light hours.

The paver shall be equipped with automatic screed controls with sensors for either or both sides of the paver, capable of sensing grade from an outside reference line, sensing the transverse slope of the screed and providing the automatic signals which operates the screed to maintain the desired grade and transverse slope. The sensor shall be so constructed that it will operate from a reference line or a ski-like arrangement.

The transverse slope controller shall be capable of maintaining the screed at the desired slope within plus or minus 0.1 percent variation.

Manual operation will only be permitted in the construction of irregularly shaped and minor areas.

Whenever a breakdown or malfunction of the automatic controls occurs, the equipment may be operated manually or by other methods in order to allow the Contractor to use the asphalt already produced at the plant or in transit, provided this method of operation will produce results otherwise meeting the specifications.

Reference lines will be required for both outer edges of the travelled way for each main line roadway for vertical control. Horizontal control utilizing the reference line will be permitted. The grade and slope for intermediate lanes shall be controlled automatically from reference lines or by means of a ski

and a slope control device or a dual ski arrangement. When the finish of the grade prepared for paving is superior to the established tolerance and, when in the opinion of the Engineer, further improvement to the line, grade, cross sections and smoothness can best be achieved without the use of the reference line, a ski-like arrangement may be substituted subject to the approval of the Engineer. The use of the reference lines shall be reinstated immediately whenever the Contractor fails to maintain a superior pavement. The Contractor shall furnish and install all pins, brackets, tensioning devices, wire and accessories necessary for satisfactory operation of the automatic control equipment.

14.3.5 Rollers

Rollers shall be steel wheel, pneumatic tired and vibratory, or a combination thereof. The roller(s) shall be in good condition, capable of reversing without backlash, and shall be operated at speeds slow enough to avoid displacement of the bituminous mixture. The number and weight of rollers shall be sufficient to compact the mixture to the required density while it is still in a workable condition. Vibratory rollers shall be acceptable for bituminous mixture compaction. The use of equipment, which results in excessive crushing of the aggregate will not be permitted.

14.3.6 Preparation of Base or Existing Pavement Surface

Before spreading materials, the surface of base or existing pavement on which the mix is to be placed shall be conditioned by application of a prime or tack coat as specified.

After a prime coat is applied, it shall be left undisturbed not less than twenty-four (24) hours. The Contractor shall maintain the primed surface until the mix material has been placed. This maintenance shall include the spreading of sand or other approved material, if necessary, to prevent adherence of the prime coat to the tyres of vehicles using the primed surface, and patching any breaks in the primed surface with additional bituminous material. Any area of primed surface that has become damaged shall be repaired before the mix is placed, to the satisfaction of Engineer. It shall be ensured that primed surface is not in tacky condition, when premix is laid.

After a tack coat is applied, it shall be allowed to dry until it is in the proper condition of tackiness to receive the mix. The tack coat shall be applied only as far in advance of the placing of mix, as is necessary to obtain the proper condition of tackiness. Any breaks in the tack coat shall be repaired.

When the surface of the existing pavement or old base is irregular, it shall be brought to uniform grade and cross-section by levelling course as directed. The levelling course mixture shall conform to the requirements of SECTION-14.2.

A thin coating of bituminous material shall be sprayed on contact surface of curbing, gutters, manholes, and other structures, prior to the bituminous

mixture being placed against them.

14.3.7 Spreading and Finishing

The mixture shall be laid upon an approved surface, spread and struck off to the section and elevation established. Bituminous pavers shall be used to distribute the mixture either over the entire width or over such partial width as may be practicable.

Care shall be taken to ensure that material is properly compacted up to joint positions. If this is not done or results in misshapen surface on a layer, the Engineer may instruct unacceptable material to be cut back before laying the adjacent material. Joints in superimposed layer of asphaltic material must be offset longitudinally by at least 2m and transversely by at least 30cm. Longitudinal joints shall, after cutting back, be of good alignment and preferably coincident with the position of carriageway markings. Except where laying in echelon, joints shall be cut back to a vertical face and Tack coated. Kerb faces, ironwork and the like in contact shall be tack coated prior to laying.

The outer edges of wearing course shall be cut back to a good alignment, parallel with the road alignment. This may require a small additional width to be laid. The Contractor should allow, within his bid rates, for this additional width and for all cutting back which will not be measured for payment. Tack coating of vertical faces will not be measured for payment.

On areas where irregularities or unavoidable obstacles make the use of mechanical spreading and finishing equipment impracticable, the mixture shall be spread, raked and luted by hand tools. For such areas, the mixture shall be dumped, spread and screeded to give the required compacted thickness, ensuring even distribution of coarse and fine material.

When production of the mixture can be maintained and wherever practical, pavers shall be used in echelon to place the wearing course in adjacent lanes and compacted to form a surface without lateral joint.

All mixture shall be spread at a temperature of not less than hundred and thirty (130) degree C and all initial rolling or tamping shall be performed when the temperature of the mixture is such that the sum of the air temperature plus the temperature of the mixture is between 165 degree C and 190-degree C. The mixture shall not be placed on any wet surface or when weather conditions will otherwise prevent its proper handling or finishing.

14.3.8 Compaction

After spreading and strike off and as soon as the mix condition permits the rolling to be performed without excessive shoving or tearing, the mixture shall be thoroughly and uniformly compacted. Rolling shall not be prolonged when cracks appear on the surface.

Initial or breakdown rolling shall be done by means of either a tandem steel roller or three-wheeled steel roller. Rolling shall begin as soon as the mixture

will bear the roller without undue displacement.

The number and weight of rollers shall be sufficient to obtain the required compaction while the mixture is still in workable condition. The sequence of rolling and the selection of roller types shall provide the specified pavement density. Initial rolling with a tandem steel roller or a three-wheeled steel roller shall follow the paver as closely as possible.

Unless otherwise directed, rolling shall begin at the lower side and proceed longitudinally, parallel to the road centreline, each trip overlapping one-half of the roller width, gradually progressing to the crown of the road. When paving in echelon or abutting a previously placed lane, the longitudinal joint should be rolled first followed by the regular rolling procedure. On super elevated curves, the rolling shall begin at the low side and progress to the high side by overlapping of longitudinal trips parallel to the centreline. Intermediate rolling with a pneumatic tired roller shall be done behind the initial rolling. Final rolling shall eliminate marks from previous rolling. In no case shall the temperature be less than hundred and twenty (120) degree C. for initial break down rolling while all other compaction operations shall be completed before the temperature drops down to hundred and ten (110) degree C.

Rollers shall move at a slow but uniform speed with the drive roll or wheels nearest the paver. Rolling shall be continued until all roller marks are eliminated and a minimum density of Ninety-eight (98) percent of a laboratory compacted specimen made from asphaltic material obtained for daily Marshall density is achieved.

Any displacement resulting while reversing the direction of a roller, or from other causes, shall be corrected at once by the use of rakes and addition of fresh mixture when required. Care shall be exercised in rolling not to displace the line and grade of the edges of the bituminous mixture.

To prevent adhesion of the mixture to the rollers, wheels of rollers shall be kept properly moistened with water or water mixed with very small quantities of detergent or other approved material. Excess liquid will not be permitted.

Along forms, curbs, headers, walls and other places not accessible to the roller, the mixture shall be thoroughly compacted with hot hand tampers, smoothing irons or with mechanical tampers. On depressed areas, tampers be used or created compression strips may be used under the roller to transmit compression to the depressed area.

Any mixture that becomes loose and broken, mixed with dirt, or is in anyway defective in finish or density shall be removed and replaced with fresh hot mixture, which shall be compacted to conform with the surrounding area. Any area showing an excess or deficiency of bituminous material shall be removed and replaced.

Sequence of laying and compaction of premix shall be so managed, that a long time does not elapse between successive dump trucks, which may cool down the un-compacted premix, between paver and compacted asphalt below 120°C

14.3.9 Frequency of Testing for Cores

One core shall be taken for each 100 linear meters of each lane of Asphaltic Base, or fraction thereof, in special cases. If the core so taken is failed against the specified 98% density, then two (2) additional cores shall be taken in the longitudinal alignment of the road at an interval of three (3) meters on either side with respect to the failing core and shall be tested against field density. If all the three cores give an average of 98% compaction, and the individual compaction of the core is not less than ninety-six (96) percent, then the compaction is acceptable. If average, of the cores further fails against compaction, then retake the cores at a distance of fifteen (15) meters on either side and compaction shall be checked for all the five cores in the same fashion. If average of five cores is 98%, the area will be accepted. In case average is 97% or more, then Engineer may withhold the payment in full or partly and observe behaviour during maintenance period. for the release of payment or otherwise. In case of failure of the average of these five cores giving average compaction of less than 97%, the failed area shall be removed and subsequently be replaced by specified mix in an approved manner at the expense of Contractor.

14.3.10 Surface Tolerances

After completion of final rolling, the finished surface shall be tested for smoothness with three (3) meters straightedge by Engineer at selected locations. The variation of surface from testing edge of straight edge between any two (2) contacts with the surface shall at no point exceed six (6) millimetres when placed either parallel or Perpendicular to centreline of roadway.

Any irregularities that exceed the specified tolerances or that retain water oil the surface shall be corrected by removing the defective area and replacing with new asphaltic base course without additional cost to the Employer.

Base Course layer tolerances shall be as given in Table 14.6. If tolerances are exceeded, the full extent of the area which does not comply with the Specification shall be determined by further sampling and testing and then made good. Unacceptable areas shall have the full depth of layer removed and replaced with fresh material. The area rectified shall be the full width of the paving laid in one operation and at least 15m long for the top layer, and 5m long for lower layers. Areas to be removed shall have their edges saw cut. Cut faces shall be coated with hot bitumen immediately before laying the new material

Table 14.6, Allowable Tolerances for Asphaltic Base Course

Sr. No.	Property	Limit	Action
1	Thickness of Layer	3mm deficiency	Full Payment
		3-10mm deficiency	85% payment
		>10mm deficiency or 15% of design thickness	Replace
2	Surface Irregularity (3m straight edge)	5 mm	Replace for greater than 5mm (minimum 30 m length of road)
3	Surface Level	6 mm	Replace for greater than 6mm (minimum 20 m length of road)

The smoothness requirements shall be supplemental with followings:

The surface irregularities will also be tested by a contractor provided, and approved by the Engineer rolling straight edge of the type designed by Transport Research Laboratory of UK, along any line or lines parallel to the edge of pavement on sections of 300 m selected by the Engineer, whether or not it is constructed in shorter lengths. Sections shorter than 300 m forming part of a longer pavement shall be assessed using the number of irregularities for a 300 m length pro rata to the nearest whole number. Where the total length of pavement is less than 300 m the measurements shall be taken on 75m length. No irregularity exceeding 10 mm shall be permitted.

The maximum permitted number of surface irregularities using a tolling straight edge are included in Table 14.7.

Table 14.7, Maximum Permitted Number of Surface Irregularities

Description	Irregularity			
	4mm		7mm	
Length, metre	300	75	300	75
Number of Irregularities	36	9	3	1

14.3.11 Base Thickness Tolerances

For determination of thickness, one (1) core for each hundred (100) linear metre of each lane shall be taken. Unless otherwise permitted, cores extracted for thickness measurement shall not be used for density determination and density cores shall not be used for thickness measurements.

When layer thickness of asphaltic base course is deficient by more than five (5) mm from that specified in the Drawings, the deficiency shall be removed with satisfactory base course material and/or made up by additional asphalt concrete wearing course thickness without extra cost to the Employer. If such remedial action is authorized, revised thickness determinations shall be made

by measurements of new cores taken after placing of "Asphaltic Wearing Course" material or as directed by the Engineer. If base course deficiencies are corrected in this manner, full payment for the "Asphaltic Base Course" will be made to the Contractor, but no additional payment will be made for the increase in thickness of the "Asphaltic Wearing Course".

14.3.12 Acceptance Sampling and Testing

Acceptance of samples and testing of materials and construction requirements, shall be governed by Table 14.8 or as approved by the Engineer.

14.3.13 Weather Limitations

Hot asphaltic mixtures shall be placed only when the air temperature is four (4) degrees centigrade or above and no asphalt shall be laid under foggy or rainy weather or over moist surface.

14.3.14 Trial Section

Contractor shall prepare a trial section before the start of work in light of procedure given in Section - 11:, GENERAL.

No extra payment shall be made for the trial section. The trial section should be minimum 200m in length and full width of the road. If the trial section has been carried out in the permanent work and approved by the Engineer, the cost of same shall be deducted from the Contract Price.

14.4 SAMPLING AND TESTING REQUIREMENT

The sampling and testing requirement for asphaltic base shall be as included in Table 14.8.

Table 14.8, Sampling & Testing Requirement of Asphaltic Base

Sr. No.	Test	Designation	Frequency
Coarse Aggregate			
1	Gradation	AASHTO T-27	1 per 1000 cubic metre
2	Abrasion	AASHTO T-96	3 per source/stock pile and 1 per 5000 cubic metre
3	Sodium Sulphate Soundness	AASHTO T-104	3 per source and 1 per 5000 cubic metre
4	Stripping	AASHTO T-182	3 per source and 2 per 5000 cubic metre
5	Fractured Faces	Visual	3 per source and as required based on visual observation
6	Flat & Elongated	Visual	3 per source and as required based on visual

Sr. No.	Test	Designation	Frequency
	Particles		observation
7	Specific Gravity & Absorption	AASHTO T-85	4 per source for each size in hot bins of Asphalt Plant
	Fine Aggregate		
8	Sand Equivalent or Plasticity Index	AASHTO T-176 AASHTO T-89 & T-90	3 per source and as required based on visual observation 2 per 1000 cubic metre
9	Specific Gravity	AASHTO T-84	4 per source
10	Friable Particles	AASHTO T-112	2 per 5000 cubic metre
	Asphalt Cement		
11	Specific Gravity	AASHTO T-228	1 per shipment
12	Penetration	AASHTO T-49	3 per week of plant operation (samples taken from heating tank at staggered intervals)
	Mixture		
13 14 15 15 17	Extraction Gradation Bulk Sp. Gravity Max. Sp. Gravity Air Voids	AASHTO T-164 AASHTO T-30 AASHTO T-166 Method B AASHTO T-209 AASHTO T-269	2 per day's production
	Mixture Compacted in Place		
18	Thickness	AASHTO T-230	1 per layer @ 100 metre interval per lane
19	Compaction	AASHTO T-230 ASTM D2950	1 per layer @ 100 metre interval per lane

14.5 MEASUREMENT AND PAYMENT

14.5.1 Measurement

The quantities for asphaltic base course will be measured by volume in cubic feet or cubic meters (whichever is included in Bill of Quantities) compacted in place. Measurements shall be based on the dimension as shown on Drawings or as otherwise directed or authorized by the Engineer. No measurement shall be made of unauthorized areas or for extra thickness.

14.5.2 Payment

The quantities determined as measured above shall be paid for at the Contract unit price for the particular pay item in the Bill of Quantities, which prices and payment shall constitute full compensation for all costs necessary for proper completion of the work prescribed in the item and approved by the Engineer. These items shall include the furnishing of all equipment labour and materials including asphalt additive or anti-stripping agent, if allowed by the Engineer to meet requirements of JMF, the drying and screening of aggregates, the mixing of bituminous material with the aggregates and the placing, furnishing and compaction of the mixed material.

Quantities of asphalt concrete mixed, wasted or disposed of in a manner not called for under the specifications or remaining on hand after completion of the work will not be paid.

SECTION - 15: INTERLOCKING CONCRETE PAVING BLOCKS

15.1 SCOPE OF WORK

The work shall consist of precast concrete paving blocks intended for the construction of low-speed roads, parking areas, lay byes, industrial and other paved surfaces subjected to all categories of static and vehicular loading and pedestrian traffic. Paving blocks covered by these Specifications are designed to form a structural element and the surfacing of pavements, having the block-to-block joints filled, so as to develop frictional interlock and placed in conformity with the lines, grades, thicknesses and typical cross-section shown on the Drawings or as directed by the Engineer.

15.2 MATERIAL REQUIREMENTS

For execution of this item provisions made in BS 6717 shall be applicable. Detailed requirement of materials and construction shall be as under:

15.2.1 Binders and Binder Constituents

Paving blocks shall be made using one or more of the following binders or binder constituents complying with the requirements of the relevant standards:

- Ordinary Portland Cement, BS 12
- Portland Blast-furnace Cement, BS 146, Part 2
- Portland Pulverized Fuel ash Cement, BS 6588
- Pulverized fuel ash, BS 3892, Part 1
- Ground granulated Blast furnace slag, BS 6699

Where pulverized fuel ash is used, the proportions and properties of the combination with Portland Cement shall comply with BS 6588.

Where ground granulated blast-furnace slag is used, the proportions and properties of the combination with Portland Cement shall comply with BS 146, Part 2.

15.2.2 Aggregates

Paving blocks shall be made using one or more of the following aggregates complying with the relevant standards:

- Natural Aggregates (Crushed or Uncrushed), BS 882:1983
- (except grading requirements in clause 5)
- Air Cooled blast-furnace slag, BS 1047:1083
- (except grading requirements in 4.8)
- Pulverized fuel ash, BS 3892, Part-1 or Part-2

- Ground granulated blast-furnace slag, BS 6699

Acid Soluble Material (Fine Aggregate), when tested as described in BS 812, Part 119, the fine aggregate (material passing a 5 mm sieve complying with BS 410) shall contain not more than 25% by mass of acid soluble material either in the fraction retained on, or in the fraction passing, a 600 micro metre sieve.

15.2.3 Water

The water shall be of drinking quality or in accordance with the recommendations of appendix A of BS 3148:1980.

15.2.4 Admixtures and Pigments

Proprietary accelerating, retarding and water reducing agents shall comply with BS 5075, Part 1.

Pigments shall comply with BS 1014.

Calcium chloride shall comply with BS 3587

15.2.5 Finishes

The finish should be agreed between the manufacturer and the Engineer.

Concrete described as “natural colour” shall contain no pigment.

In composite paving blocks the surface layer shall be formed as an integral part of the block and shall be not less than 5 mm thick.

15.2.6 Binder Content

The cement content of the compacted concrete shall be not less than 380 kg/m³. For equivalent durability, paving blocks made with binder constituents other than ordinary Portland cement shall have a higher binder content than paving blocks made in a similar way using only Portland Cement. The Engineer will decide the additional binder content. The compressive strength test will be the only guide to the amount of additional binder needed.

15.2.7 Sizes and Tolerances

A) Sizes

Paving blocks shall have a work size thickness of not less than 60 mm. Type-R blocks shall be rectangular with a work size length of 200 mm and a work size width of 100 mm. Type-S blocks shall be of any shape fitting within a 295 mm square coordinating space and shall have a work size width not less than 80 mm.

The preferred work size thicknesses are 60 mm, 65 mm, 80 mm & 100 mm.

A chamfer around the wearing surface with a work size not exceeding 7 mm in width or depth shall be permitted.

All arrises shall be of uniform shape.

B) Tolerances

The maximum dimensional deviations from the stated work sizes for paving blocks shall be as follows:

- length ± 2 mm
- width ± 2 mm
- thickness ± 3 mm

Where a paving block includes profiled sides, the profile shall not deviate from the manufacturer's specification by more than 2 mm.

15.2.8 Compressive Strength

The compressive strength of paving blocks shall be not less than 49 N/mm² and the crushing strength of any individual block shall be not less than 40 N/mm².

15.2.9 SAMPLING

The following sampling procedure shall be used for the compressive strength test.

- a) Before laying paving blocks, divide each designated section, comprising not more than 5000 blocks, in a consignment into eight approximately equal groups, clearly mark all samples at the time of sampling in such a way that the designated section or part thereof and the consignment represented by the sample are clearly defined. Take two (2) blocks from each group.
- b) Dispatch the sample to the test laboratory, taking precautions to avoid damage to the paving blocks in transit. Each sample shall be accompanied by a certificate from the person responsible for taking the sample, stating that sampling was carried out in accordance with this Part of BS 6717.
- c) Protect the paving blocks from damage and contamination until they have been tested. Carry out any tests as soon as possible after the sample has been taken.

15.2.10 Marking

The following particulars relating to paving blocks made in accordance with this standard shall be indicated clearly on the delivery note invoice, manufacturer's or supplier's certificate or brochure supplied with the consignment of blocks:

- a) The name, trade mark or other means of identification of the manufacturer.

- b) The number and date of this British Standard, i.e., BS 6717, Part 1, latest revision.

15.3 CONSTRUCTION REQUIREMENTS

15.3.1 Laying the Concrete Blocks

The total area to be covered with paving block shall be prepared by:

- a. Compaction of subgrade
- b. Laying of subbase in a thickness specified
- c. Laying of crushed aggregate base or lean concrete in thickness as per typical section

15.3.2 Tolerance

Tolerance of these layers shall be as per applicable requirement of each item of these specifications.

Payment for each of the above item shall be made under the relative item of work.

The total area will thereby be divided with nylon strings into sectors of not more than 1.5 square meters. This shall be done to control the alignment of paving blocks and to avoid multiplication of deviation in sizes of paving blocks.

15.4 MEASUREMENT AND PAYMENT

15.4.1 Measurement

The area to be measured shall be bound by lines shown on the Drawings or as directed by the Engineer. Unit of measurement shall be square metre or square feet (whichever is included in Bill of Quantities), measured in horizontal plane.

15.4.2 Payment

The quality determined as provided above shall be paid for the unit price of contract for each square metre or square feet (whichever is included in Bill of Quantities) of paving block installed including sand cushion and sand filling in joints and all other work related for installing paving blocks. Cost shall include all labour, materials and equipment for proper completion of work.

PART - 4: SURFACE TREATMENT FOR ROADS

SECTION - 16: GENERAL

16.1 GENERAL

This section describes the requirements and procedures for execution of surface courses and pavements. The materials to be used shall conform to specifications and testing procedures as per American Association of State Highway and Transportation Official (AASHTO) or the American Society for Testing and Material (ASTM) as indicated in their latest editions or, for particular materials or procedures, the British Standards Institution. Samples of materials for laboratory tests and their subsequent approvals shall be utilized according to these references unless otherwise directed by the Engineer.

Materials which do not conform to the requirements of these specifications will be rejected whether in place or not. They shall be removed immediately from the site of the work at the expense of Contractor. While subgrade/subbase and paving operations are in progress, a detour shall be provided for vehicular flow in order to avoid any public inconvenience and thoroughly be maintained till completion of that particular section of the project or as a whole. In order to expedite the passage of public traffic through or around the work, the Contractor shall install road signs, warning lights, flares, barricades and other facilities for the safety, convenience and direction of public traffic. Also, where directed by the Engineer, the Contractor shall furnish competent flagmen whose sole duties shall consist of directing the movement of public traffic through or around the work. The cost of furnishing and installation of such road-signs, lights, flares barricades and other facilities, shall be included in the respective work item. Should the Engineer point out the inadequacy of warning and protective measures, and require additional measures, such action on the part of the Engineer shall not relieve the Contractor from responsibility for public safety or abrogate his obligation to furnish and pay for these services.

SECTION - 17: ASPHALTIC MATERIALS

17.1 ASPHALT CEMENT

Asphalt Cement shall be an oil asphalt, or a mixture of refined liquid asphalt and refined solid asphalt, prepared from crude asphaltic petroleum. It shall be free from admixture with any residues obtained by the artificial distillation of coal, coal tar, or paraffin and shall be homogeneous and free from water. No emulsification shall occur when a thirty (30) gram sample is boiled for two (2) hours with two hundred and fifty (250) cubic centimetres of distilled water in a five hundred (500) cubic centimetres Erlenmeyer flask equipped with a reflux condenser.

Asphalt Cement shall be classified by penetration and when tested in accordance with the standard methods of tests of the AASHTO, the grades of asphalts shall conform to the requirements set forth in Table 17.3. The grade of asphalt to be used shall be in accordance with these specifications or the Special Provisions or as directed by the Engineer.

17.2 ENVIRONMENTAL FACTORS

In areas where highly frost susceptible soils and severe low temperature conditions are encountered, it may be necessary to remove and replace soils susceptible to frost heave or take other precautions prior to pavement construction. In extremely hot climates, asphalt mixes should be designed to resist rutting and maintain stiffness at high temperatures.

Because asphalt mixtures are influenced by temperature, it is recommended that different asphalt grades be used where different temperature conditions prevail. Table 17.1, gives recommended asphalt grades for various temperature conditions.

Table 17.1, Selecting Asphalt Grade based on Environment

Sr. No.	Criteria	Requirement
1	Cold, mean annual air temperature $\leq 7^{\circ}\text{C}$ (45°F)	AC-10 AR-4000 80/100 penetration
2	Warm, mean annual air temperature between 7°C (45°F) and 24°C (75°F)	AC-20 AR-8000 60/70 penetration
3	Hot, mean annual air temperature $\geq 24^{\circ}\text{C}$ (75°F)	AC-40 AR-16000 40/50 penetration

* Both medium setting (MS) and slow setting (SS) emulsified asphalts are used in emulsified asphalt base mixes. They can be either of two types: cationic

(ASTM D 2397 or AASHTO M 208) or anionic (ASTM D977 or AASHTO M 140). Selecting one of the two shall depends on the type of aggregate used for better affinity.

The grade of emulsified asphalt is selected primarily on the basis of its ability to satisfactorily coat the aggregate. This is determined by coating and stability test (ASTM D 244, AASHTO T 59). Other factors important in the selection are the water availability at the job site, anticipated weather at the time of construction, the mixing process to be used, and the curing rate.

17.3 CUT-BACK ASPHALT

Liquid asphalts (cut back) shall consist of materials conforming to the following classifications. When tested in accordance with the standard methods of tests of the AASHTO, the grades of liquid asphalt shall conform to the requirements specified in the Table 17.4 and Table 17.5.

Medium curing products designated by letters MC, shall consist of asphalt cement fluxed or blended with a kerosene solvent.

Rapid curing products designated by the letters RC, shall consist of asphalt cement with a penetration of grade 80-100, fluxed or blended with a naphtha solvent.

17.4 EMULSIFIED ASPHALT

Asphaltic emulsions shall be composed of a bituminous base uniformly emulsified with water and an emulsifying or stabilizing agent. They shall be classified according to use as Rapid Setting or Slow Setting, and shall conform to the requirements specified in Table 17.6.

The bituminous base used in manufacturing RS-1 type emulsion shall be asphalt cement, Grade 120-150 or Grade 200-300, as designated by the Engineer.

The bituminous base used in manufacturing SS-1 type emulsion shall be paving asphalt, Grade 60-70 or Grade 120-150, as designated by the Engineer.

Table 17.2, Application Temperature Range, °C

Sr. No.	Asphalt Grade	Mixing Temperature	Spraying Temperature Road Mixes
1	Asphalt Cement (all grades)	As required to achieve viscosity of 75-150 secs. Saybolt- Furoil or as required to achieve a Kinematic Viscosity	160 (max)

Sr. No.	Asphalt Grade	Mixing Temperature	Spraying Temperature Road Mixes
		of 150-300 centistokes	
2	Emulsified Asphalts		
	RS-1	-	-
	RS-2	-	-
	MS-1	10-70	20-70
	MS-2	10-70	20-70
	MS-2h	10-70	20-70
	HFMS-1	10-70	20-70
	HFMS-2	10-70	20-70
	HFMS-24	10-70	20-70
	SS-1	10-70	20-70
	SS-1h	10-70	20-70
	CRS-1	10-70	20-70
	CRS-2	-	-
	CMS-2	-	-
	CMS-2h	10-70	20-70
	CSS-1	10-70	20-70
	CSS-1h	10-70	20-70
3	Cutback Asphalts (RC, MC, SC)		
	30 (MC only)	-	-
	70	-	20 min.
	250	55-80	40 min.
	800	75-100	55 min.
	3000	80-115	-

Table 17.3, Requirement for Asphalt Cement (AASHTO M-20)

Sr. No.	Criteria	Penetration Grade							
		40 - 50		60 - 70		80 - 100		120 - 150	
		Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
1	Penetration at 77°F (25°C) 100g 5 sec	40	50	60	70	80	100	120	150
2	Flash point, Cleveland Open Cup, °F (°C)	450 (232)	-	450 (232)	-	450 (232)	-	425 (218)	-
3	Ductility at 77°F (25°C) 5cm per min, cm	100	-	100	-	100	-	100	-
4	Solubility in Trichloroethylene, percent	99	-	99	-	99	-	99	-
5	Thin-film oven test, 1/8 in (3.2mm), 325°F (163°C) 5-hour Loss on heating, percent	-	0.80	-	0.80	-	1.0	-	1.3
6	Penetration, of residue, percent of original	58	-	54	-	50	-	46	-
7	Ductility of residue at 77°F (25°C) 5-cm per minute, cm	-	-	50	-	75	-	100	-

Table 17.4, Requirement for Medium-Curing Type Asphalts (AASHTO M-82)

Sr. No.	Criteria	MC-70		MC-250		MC-800	
		Min.	Max.	Min.	Max.	Min.	Max.
1	Water, percent	-	0.2	-	0.2	-	0.2
2	Flash point, tag. open cup, °C	38	-	66	-	66	-
3	Kinematic viscosity at 60°C (140°F), Centistokes (see note 1)	70	140	250	500	800	1600
4	Distillation Test, distillate, percentage by volume of total distillate at 360°C (680°F)						
a)	225°C (437°F)	0	20	0	10	-	-

Sr. No.	Criteria	MC-70		MC-250		MC-800	
		Min.	Max.	Min.	Max.	Min.	Max.
b)	260°C (500°F)	20	60	15	55	0	35
c)	315°C (600°F)	65	90	60	87	45	80
5	Residue from distillation at 360°C (680°F), volume percentage of sample by difference	55	-	67	-	75	-
6	Tests on residue from distillation:						
a)	Penetration, 100g, 5 sec, at 25°C (77°F)	120	250	120	250	120	250
b)	Ductility, 5 cm/min, cm (see note 2)	100	-	100	-	100	-
c)	Solubility in Trichloroethylene, percent	99	-	99	-	99	-

Note:

- As an alternate, Saybolt Furol viscosities may be specified as following:
Grade MC-70 Furol Viscosity at 50°C (122°F) 60 to 120 Sec.
Grade MC-250 Furol Viscosity at 60°C (140°F) 125 to 250 Sec.
Grade MC-800 Furol Viscosity at 82.2°C (180°F) 100 to 200 Sec.
- If penetration of residue is more than 200 and its ductility at 25°C (77°F) is less than 100 cm, the material will be acceptable if its ductility at 15.5°C (60°F) is more than 100 cm.

Table 17.5, Requirement for Rapid-Curing Type Asphalts (M-81)

Sr. No.	Criteria	RC-70		RC-250		RC-800	
		Min.	Max.	Min.	Max.	Min.	Max.
1	Water, percent	-	0.2	-	0.2	-	0.2
2	Flash point, tag. open cup, °C	-	-	27	-	27	-
3	Kinematic viscosity at 60°C (140°F), Centistokes (see note 1)	70	140	250	500	800	1600
4	Distillation Test, distillate, percentage by volume of total distillate at 360°C (680°F)						

Sr. No.	Criteria	RC-70		RC-250		RC-800	
		Min.	Max.	Min.	Max.	Min.	Max.
a)	190°C (374°F)	10	-	-	-	-	-
b)	225°C (437°F)	50	-	35	-	15	-
c)	260°C (500°F)	70	-	60	-	45	-
d)	315°C (600°F)	85	-	80	-	75	-
5	Residue from distillation at 360°C (680°), volume percentage of sample by difference	55	-	65	-	75	-
6	Tests on residue from distillation:						
a)	Penetration, 100g, 5 sec, at 25°C (77°F)	80	120	80	120	80	120
b)	Ductility, 5 cm/min, cm (see note 2)	100	-	100	-	100	-
c)	Solubility in Trichloroethylene, percent	99	-	99	-	99	-

Note:

- As an alternate, Saybolt Furol viscosities may be specified as following:

Grade RC-70	Furol Viscosity at 50°C (122°F)	60 to 120 Sec
Grade RC-250	Furol Viscosity at 60°C (140°F)	125 to 250 Sec
Grade RC-800	Furol Viscosity at 82.2°C (180°F)	100 to 200 Sec

Table 17.6, Requirement for Asphalt Cement (AASHTO M-20)

Sr. No.	Criteria	Rapid Setting				Slow Setting			
		RS - 1		RS - 2		SS - 1		SS - 2	
		Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
	Test on Emulsions:								
1	Viscosity, Saybolt Furol at 77°F (25°F), Sec	20	100	-	-	20	100	20	100
2	Viscosity, Saybolt Furol at 122°F (50°F), Sec	-	-	97	400	-	-	-	-

Sr. No.	Criteria	Rapid Setting				Slow Setting			
		RS - 1		RS - 2		SS - 1		SS - 2	
		Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
3	Settlement 5 days, percent (see note 1)	-	5	-	5	-	5	-	5
4	Storage Stability test, 1 day (see note 2)	-	1	-	1	-	1	-	1
5	Demulsibility, 35 ml, 0.02N CaCl ₂ , percent	60	-	60	-	-	-	-	-
6	Cement mixing test, percent	-	-	-	-	-	2	-	2
7	Sieve test, percent	-	0.10	-	0.10	-	0.10	-	0.10
8	Residue by distillation, percent	55	-	63	-	57	-	57	-
9	Test on Residue from Distillation Test Penetration, 77° (25°C) 100g 5 Sec	100	200	100	200	100	200	40	90
10	Ductility, 77°F (25°C), 5 cm/min, cm	40	-	40	-	40	-	40	-
11	Solubility in trichloroethylene, percent	97.5	-	97.5	-	97.5	-	97.5	-
	Suggested uses	Surface treatment, penetration macadam and tack coat		Surface treatment & penetration macadam		Plant or road mixture with graded and fine aggregate, a substantial quantity of which passes a No. 8 (2.3mm) sieve and a portion of which may pass a No. 200 (0.075 mm) sieve; slurry seal treatments			

Note:

1. The test requirement for settlement may be waived when the emulsified asphalt is used in less than 5 days' time; or the Engineer may require that the settlement test be run from the time the sample is received until it is used, if the elapsed time is less than 5 days
2. The 24-hr (1 day) storage stability test may be used instead of the 5 days settlement test.
3. The demulsibility test shall be made within 30 days from date of shipment.

SECTION - 18: BITUMINOUS PRIME COAT

18.1 SCOPE OF WORK

This work shall consist of furnishing all plant, labour, equipment, material and performing all operations in applying a liquid asphalt prime coat on a previously prepared and untreated; earth sub grade, water bound base course, crushed aggregate base course, tops of roadway shoulders, and as otherwise shown on the Drawings in strict accordance with the specification and in conformity with the lines shown on the Drawings.

18.2 MATERIAL REQUIREMENTS

Asphaltic material shall conform to the requirements of the Section - 17; ASPHALTIC MATERIALS, either cutback or Emulsified Asphalt, whichever is specified in the Bill of Quantities.

18.3 CONSTRUCTION REQUIREMENTS

Prior to the application of prime coat loose material, dirt and other objectionable material shall be removed from the surface and the surface shall be cleaned by mechanical sweepers blowers supplemented with hand brooms. The application is prohibited when the weather is foggy or rainy or when the atmospheric temperature is below fifteen (15) degree C unless otherwise directed by the Engineer. On a soil surface or sub base or base course, the cleaned surface shall be given a light application of water and allowed to dry to a surface dry condition before prime coat is applied. No traffic shall be permitted on the surface after it has been prepared to receive the bituminous material. Moreover, all expansion joints shall be cleaned and filled with bituminous material as directed by the Engineer. Areas to be primed will be classified as under:

- a. The top of earth surface or water bound base courses from a point twenty (20) centimetres outside the edge of the pavement line to 20 cm outside the line on the opposite side of the roadway.
- b. The top of the shoulders from the inter-section of embankment slope and top of subgrade to the edge of the pavement line.
- c. The bridge wearing surface from curb to curb and end to end of bridge wearing surface.
- d. Other surfaces as shown on the Drawings or ordered by the Engineer.

Primed surface shall be kept undisturbed for at least 24 hours, so that the bituminous material travels beneath and leaves the top surface in non-tacky condition. No asphaltic operations shall start on a tacky condition.

18.3.1 Equipment

The liquid asphaltic material shall be sprayed by means of a pressure distributor of not less than 1000 litre capacity, mounted on pneumatic tyres of such width and number that the load produced on the road surface will not exceed hundred (100) kg per cm width of tyre. It shall be of recognized manufacturer.

The tank shall have a heating device able to heat a complete charge of asphaltic liquid up to one hundred eighty (180) degree C. The heating device shall be so that overheating will not occur. Consequently, the flames must not touch directly on the casting of the tank containing the asphaltic liquid or gases therefrom. The Contractor will be responsible for any fire or accident resulting from heating of bituminous materials. The liquid shall be circulated or stirred during the heating. The tank shall be insulated in such a way that the drop-in temperature when the tank is filled and not heated, will be less than two (2) degree C per hour. A thermometer shall be fixed to the tank in order to be able to control continuously the temperature of the liquid. The thermometer shall be placed in such a way that the highest temperature in the tank is measured. The tank shall be furnished with a device that indicates the contents. The pipes for filling the tank shall be furnished with an easily interchangeable filter.

The distributor shall be able to vary the spray width of the asphaltic liquid in steps of maximum 10 cm, to a total width of four (4) metre. The spraying bar shall have nozzles from which the liquid is sprayed fan-shaped on the road surface equally distributed over the total spraying width.

The distributor shall have a pump for spraying the liquid driven by a separate motor, or the speed of the pump shall be synchronized with the speed of the distributor. The pump shall be furnished with an indicator showing the performance in litres per minute. At the suction side the pump shall have a filter easily exchangeable. A thermometer shall be fixed, which indicates the temperature of the liquid immediately before it leaves the spraying bar.

The distributor shall be furnished with a tachometer indicating the speed in metre per minute. The tachometer shall be visible from the driver's seat. The function of the distributor shall be so exact that the deviation from the prescribed quantity to be spread on any square metre does not exceed 10%.

The distributor shall be equipped with a device for hand spraying of the bituminous liquid, to cover any irregular area or covering the area improperly sprayed.

18.3.2 Application of Asphaltic Material

Immediately before applying prime coat, the full area of surface to be treated shall be swept with a power broom to remove all dirt and other objectionable material. If required by the Engineer, the surface shall be made moist but not saturated. Asphaltic Materials shall be applied at

temperature stated in Section - 17: by approved pressure distributors operated by skilled workmen. The spray nozzles and spray bars shall be adjusted and frequently checked so as to ensure uniform distribution. Spraying shall cease immediately upon any clogging or interference of any nozzle and remedial measures taken before spraying is resumed.

The rate for application of asphaltic material (cut back/emulsified) shall be as included in Table 18.1.

Table 18.1, Application Rate of Asphaltic Material

Sr. No.	Type of Surface	Litre per Square Meter	
		Minimum	Maximum
1	Sub-grade, Sub-base, Water bound base courses, and Crushed stone base course	0.65	1.75
2	Bridge, Wearing Surfaces, Concrete Pavement	0.15	0.40

However, the exact rate shall be specified by the Engineer determined from field trials.

The test methods shall be determined by the Engineer and performed by the Contractor in the presence of Engineer.

The prime coat shall be left undisturbed for a period of at least 24 hours, and shall not be opened to traffic until it has penetrated and cured sufficiently so that it will not be picked up by the wheels of passing vehicles. The Contractor shall maintain the prime coat until the next course is applied. Care shall be taken that the application of bituminous material is not in excess of the specified amounts; any excess shall be blotted with sand or similar treatment. All areas inaccessible to the distributor shall be sprayed manually using the device for hand spraying from the distributor.

The surface of structures and trees adjacent to the area being treated shall be protected in such manner as to prevent their being spattered or marred.

Where no convenient detour is available for traffic, operations shall be confined to one-half the roadway width at a time. The Contractor shall provide proper traffic control so that vehicles may proceed without damage to the primed area. Work shall not be started on the portion of the road not covered by previous application until the surface previously covered has dried and is ready for traffic.

18.4 MEASUREMENT AND PAYMENT

18.4.1 Measurement

The unit of measurement shall be square foot or square metre (whichever is included in Bill of Quantities) as actually covered by prime coat in accordance with these specifications. No measurement or payment will be

made for the areas primed outside the limits, specified, herein, shown on the Drawings or designated by the Engineer.

Blotting material will not be measured for payment and shall be considered subsidiary to the prime coat.

18.4.2 Payment

The payment for area primed measured as stated above, shall be made for the contract unit price per square foot or square metre (whichever is included in Bill of Quantities), which payment shall be full compensation for furnishing all labour, material, tools, equipment and incidentals and for performing all the work involved in applying prime coat, complete in place in accordance with these specifications.

SECTION - 19: BITUMINOUS TACK COAT

19.1 SCOPE OF WORK

The work covered by this section shall consist in furnishing all plant, labour, equipment and applying asphaltic material on a previously prepared asphaltic layer, in addition to performing all operations in connection with the application of a Bituminous tack coat, complete in accordance with these specifications and to the width shown on the typical cross- sections of applicable Drawings.

19.2 MATERIAL REQUIREMENTS

Asphaltic material shall conform to the requirements of Section - 17:, ASPHALTIC MATERIALS for emulsified asphalt, or cut back asphalt as called for in the Bill of Quantities.

19.3 CONSTRUCTION REQUIREMENTS

Immediately before applying the tack coat, all loose material, dirt or other objectionable material, shall be removed from the surface to be treated by power brooms and/or blowers, supplemented with hand brooms, as directed by the Engineer. The tack coat shall be applied only when the surface is dry, however for emulsified asphalt, application may be made on a reasonable moist surface. Application of tack coat shall be avoided in case of foggy or rainy weather. Prior to the application, an inspection of the prepared surface will be made by the Engineer to determine its fitness to receive the bituminous binder and no tack coat will be applied until the surface has been approved.

19.3.1 Equipment

Equipment shall conform in all respect to the provision SECTION-18.3.1 and shall be subject to the approval of the Engineer in addition to the maintenance of the same in a satisfactory working condition at all times. A hand power spray attachment to a bitumen pressure distributor or other container having an independently operated bitumen pump, pressure gauge, thermometer for determining the temperature of the asphalt tank contents and a hose connected to a hand power spray suitable for applying the Bituminous tack coat in the amounts specified, all to be such as to meet the approval of the Engineer, shall be furnished.

19.3.2 Application of Asphaltic Material

Asphaltic material shall be applied by means of a pressure distributor, at the temperature stated in Section - 17: for the particular material being used. Rates of application of cut back shall be within the range of 0.2-0.4 litres per square metre and for emulsified asphalt the rate shall be within the range of

0.3-0.6 litre per square metre; the exact rate shall be specified by the Engineer. Care shall be taken that the application of asphaltic material is not in excess of the specified quantity; any-excess asphalt shall be blotted by sand or similar treatment. All areas inaccessible to the distributor shall be treated manually using the device for hand spraying from the distributor. The surfaces of structures and trees adjacent to the areas being treated shall be protected in such a manner as to prevent their being spattered or marred.

Where no convenient detour is available for traffic, operations shall be confined to on the roadway width at a time. The Contractor shall provide proper traffic control so that vehicles may proceed without damage to the treated area. Work shall not be started on the portion of the road not covered by previous application until the surface previously covered has dried and is ready for paving. Traffic shall be kept off the tack coat at all times. The tack coat shall be sprayed only so far in advance of the surface course as will permit it to dry to a "tacky" condition. The Contractor shall maintain the tack coat until the next course has been placed. Any area that has become fouled, by traffic or otherwise, shall be cleaned by Contractor at his own cost before the next course is applied.

19.4 MEASUREMENT AND PAYMENT

19.4.1 Measurement

The quantities of Bituminous Tack Coat shall be measured in square foot or square metre (whichever is included in Bill of Quantities) for the actual area tacked with asphaltic material on the prepared surface in accordance with this specification.

19.4.2 Payment

The payment of bituminous tack coat, measured as stated above shall be paid for at the contract unit price per square foot or square metre (whichever is included in Bill of Quantities), which payment shall be full compensation for furnishing all labour, materials, tools, equipment and incidentals and for performing all the work involved in applying Tack Coat complete in place, as shown on the Drawings and in accordance with these specifications.

SECTION - 20: ASPHALT CONCRETE WEARING COURSE

20.1 SCOPE OF WORK

This work shall consist of furnishing aggregates and asphalt binder at a central mixing plant, to a specified mixing temperature, transporting, spreading and compacting the mixture in an approved manner on primed or tacked base, subbase, subgrade, bridge deck or concrete pavement in accordance with these specifications and in conformity with the lines, grades and typical cross-sections shown in the Drawings or as directed by the Engineer.

20.2 MATERIAL REQUIREMENTS

20.2.1 Mineral Aggregates

The Aggregates shall consist of coarse aggregates, fine aggregates and filler material, if required and shall be clean, hard, tough, durable and sound particles of uniform quality, geology, petrology and free from decomposed material, vegetable matter, soil, clay, lumps and other deleterious substances.

Coarse aggregate which is the material retained on an AASHTO No. 4 Sieve, shall consist of one hundred (100) % crushed rock or crushed gravel having two (2) faces mechanically crushed. The type of source shall be uniform throughout the quarry location from where such a material is obtained. The coarse aggregates shall be free from an excess of flat or/and elongated particles.

Fine aggregate which is the material passing from AASHTO No. 4 sieve, shall consist of 100% crushed material from rock or boulder. Fine aggregate shall be stored separately, and no natural sand will be allowed in the mix.

When the combined grading of the coarse and fine aggregates is deficient in material passing the AASHTO No. 200 sieve, mineral filler material shall be added as approved by the Engineer. The filler shall consist of finely divided mineral matter such as rock dust, hydrated lime, hydraulic, calcined dust cement or other suitable mineral matter free from lumps, balls or other deleterious material and shall conform to the gradation as included in Table 20.1.

Table 20.1, Filler Material for Asphalt Concrete Wearing Course

Sr. No.	Sieve Designation		Percent Passing by Weight
	mm	Inch	
1	0.600	No.30	100
2	0.300	No.50	95-100
3	0.075	No.200	70-100

The coarse and fine aggregates shall meet the following requirements:

- a. The percent of wear by the Los Angeles Abrasion test (AASHTO T 96) shall not be more than thirty (30).
- b. The loss when subjected to five cycles of the Sodium Sulphate Soundness test (AASHTO T 104) shall be less than twelve (12) percent.
- c. The Sand Equivalent (AASHTO T 176) determined after all processing except for addition of asphalt cement shall not be less than 45.
- d. All aggregates shall have a liquid limit of not more than twenty-five (25) and a Plasticity Index of not more than four (4) as determined by AASHTO T-89 and T-90.
- e. The portion of aggregates retained on the 9.5 mm (3/8 inch) sieve shall not contain more than 10 percent by weight of flat and/or elongated particles (ratio of maximum to minimum dimension = 2.5:1).
- f. Stripping test shall be performed on crush aggregates as described under AASHTO-182 and only that material shall be allowed which qualifies the test.
- g. The coarse aggregates shall be checked if desired by the Engineer for cationic and anionic behaviour so that their affinity with the bitumen to be used is verified.
- h. Petrographic examination of the coarse aggregate shall be conducted if so directed by the Engineer.

The percentage of particles having certain proportions between their largest and smallest dimensions (i.e., between the largest distance the particles can fill out between two parallel planes that will permit the particle to pass), shall be determined in the following way:

- a. Form a sample of coarse aggregates, all particles passing No. 4 sieve are eliminated. The sample shall be of sufficient quantity that at least 100 particles remain.
- b. By means of a sliding calliper, the largest and smallest dimensions, as defined above, are determined for each particle and its proportion calculated (with one decimal).
- c. The total weights of particles having the proportions two and a half (2.5) or less and three (3) or less, are determined and their percentage in relation to the total sample are calculated.

20.2.2 Asphaltic Material

Asphalt binder to be mixed with the aggregate to produce asphaltic concrete shall be asphalt cement penetration grade 60-70 or a grade

approved by the Engineer. Generally, it will meet the requirements of AASHTO M-20.

20.2.3 Asphalt Concrete Wearing Course Mixture

The composition of the asphaltic concrete paving mixture for wearing course shall conform to Class A and/or Class B as included in Table 20.2.

Table 20.2, Asphalt Concrete Wearing Course Requirements

Compacted Thickness			50-80 mm	35-60 mm
Sr. No.	Sieve Designation		Percent Passing by Weight	
	mm	inch	Class A	Class B
1	25.0	1	100	-
2	19.0	3/4	90-100	100
3	12.5	1/2	-	75-90
4	9.5	3/8	56-70	60-80
5	4.75	No.4	35-50	40-60
6	2.38	No.8	23-35	20-40
7	1.18	No.16	5-12	5-15
8	0.075	No.200	2-8	3-8
Asphalt Content by Weight percent of total mix			3.5 (min.)	3.5 (min.)

However, Class B composition of the asphaltic concrete paving mixture for wearing course is recommended for this project.

The asphalt concrete wearing course mixture shall meet the Marshal Test Criteria as included in Table 20.3.

Table 20.3, Marshal Test Criteria

Sr. No.	Criteria	Requirement
1	Compaction, number of blows each end of specimen	75
2	Stability	1000 kg (min.)
3	Flow, 0.25 mm (0.01-inch)	8 – 14
4	Percent air voids in mix	3.5 – 5.5
5	Percent voids in mineral aggregates	
6	Loss in Stability	20 percent (max.)

20.2.4 Job-Mix Formula

At least one week prior to production, a Job-Mix Formula (JMF) for the asphaltic wearing course mixture or mixtures to be used for the project, shall be established jointly by the Engineer and the Contractor.

The JMF shall be established by Marshall Method of Mix Design according to

the procedure prescribed in the Asphalt Institute Manual Series No. 2 (MS-2), sixth edition 1993 or the latest Edition.

The JMF, with the allowable tolerances, shall be within the master range specified in Table 304-1. Each JMF shall indicate a single percentage of aggregate passing each required sieve and a single percentage of bitumen to be added to the aggregates.

The ratio of weight of filler (Passing No. 200) to that of asphalt shall range between 1 - 1.5 for hot climate areas with temperature more than 40°C.

Prior to the final approval, the proposed job mix, with a bitumen content at the permissible upper percentage limit determined in JMF, shall be compacted to refusal (400 to 600 blows) and the resulting air voids in the mix shall not be less than 2%.

After the JMF is established, all mixtures furnished for the project represented by samples taken from the asphalt plant during operation, shall conform thereto with the ranges of tolerances as included in Table 20.4.

Table 20.4, Adjustment of Plant based on Marshall Test

Sr. No.	Description	Range
1	Maximum Variation of Percentage of Materials	
	Retained No.4 and Larger	± 7.0%
	Passing No.4 to No.100 Sieve	± 4.0%
	Passing No.200	± 1.0%
2	Asphalt Content	
	Weight Percent of Total Mix	± 0.2%

In addition to meeting the requirements specified in the preceding items, the mixture as established by the JMF shall also satisfy the following physical property:

Loss of Marshall Stability by immersion of specimen in water at sixty (60) degree C for twenty-four (24) hours as compared with the stability measured after immersion in water at sixty (60) degree C for twenty (20) minutes shall not exceed twenty (20) percent. If the mixture fails to meet this criterion, the JMF shall be modified or an anti-stripping agent shall be used.

Should a change of sources of materials be made a new Job Mix Formula shall be established before the new material is used. When unsatisfactory results or other conditions make it necessary, a new Job Mix Formula will be required.

When the Engineer is satisfied that JMF proposed by the Contractor conforms to all the requirements of the specifications, he shall order the Contractor to construct a two hundred (200) metre long field control strip. The Engineer shall

evaluate the control strip as to its constructability and compactability and the mix for conformance to the laboratory tested JMF within the tolerances. If the Engineer is not satisfied with the results of the control strip, he shall state his objections in writing and request a revised JMF and a new control strip. The control strip may only be left in place if the results are satisfactory.

When the Engineer is satisfied that the JMF proposed by the Contractor conforms to all requirements of the specification and control strip results are acceptable, he will issue written acceptance to the Contractor to begin producing the mixes proposed. Production of bituminous concrete mixtures shall not begin until the Engineer has given written acceptance of the Job Mix Formula.

Acceptance of the JMF by the Engineer does not relieve the Contractor of his obligation to produce bituminous concrete mixtures conforming to all specified requirements

20.3 CONSTRUCTION REQUIREMENTS

Construction requirements for this Item shall conform with the same as specified for Asphaltic Concrete Base Course (Plant Mix) under SECTION-14.3, except as modified in the following sub-items.

20.3.1 Preparation of Base Course Surface

Before spreading materials, the surface of the previously constructed and accepted base course on which the mix is to be placed shall be conditioned by application of a tack coat, if directed by the Engineer.

20.3.2 Pavement Thickness and Tolerances

The asphalt concrete wearing course shall be compacted to the desired level and cross slope as shown on the drawing or as directed by the Engineer.

The tolerances in compacted thickness of the wearing course shall be ± 3 mm from the desired thickness shown on the Drawings. For determination of thickness one (1) core per hundred meters of each lane will be taken. If the thickness so determined is deficient by more than three (3) mm, but not more than five (5) mm, payment will be made at an adjusted price as specified in Table 20.9.

After the wearing course has been completed, cores for full depth of asphalt base course and wearing course shall be taken for determining the thickness. Thickness of wearing course shall be considered to be equal to the thickness obtained by subtracting design thickness of asphalt base course from total thickness of core.

The surface of the wearing course shall be tested by the Engineer using a 5 meters straightedge at selected locations. The variation of the surface from the testing edge of the straightedge between any two contacts, longitudinal or transverse with the surface shall at no point exceed five (5) millimetres. The

cross fall (camber) shall be with ± 0.2 percent of that specified, and the level at any point shall be within $\pm$ three (3) mm of the level shown on the Drawings. All humps or depressions exceeding the specified tolerance shall be corrected by removing the defective work and replacing it with new material, by overlaying, or by other means satisfactory to the Engineer.

The surface irregularities will also be tested by, contractor provided, and approved by the Engineer rolling straight edge of the type designed by Transport Research Laboratory of UK, along any line or lines parallel to the edge of pavement on sections of 300m selected by the Engineer, whether or not it is constructed in shorter lengths. Sections shorter than 300m forming part of a longer pavement shall be assessed using the number of irregularities for a 300m length prorata to the nearest whole number. Where the total length of pavement is less than 300m the measurements shall be taken on 75m length. No irregularity exceeding 5mm shall be permitted.

Table 20.5, Maximum Permitted Number of Surface Irregularities

Description	Irregularity	
	5mm	
Length, metre	300	75
Number of Irregularities	20	5

In addition to meeting the other conditions as specified herein, the Contractor shall be responsible to ensure satisfactory riding quality of asphaltic wearing course in terms of IRI (International Roughness Index). The riding quality shall be checked at the time of making measurements of the item, handing over and subsequently at the end of one year period or at any intermediate interval as deemed necessary by the Engineer.

The Contractor shall perform roughness evaluation in terms of IRI for smoothness of the surface. The Contractor shall arrange all the equipment including profilometer of acceptable model and make for this purpose. The equipment shall be calibrated as per instructions/recommendations of the manufacturer and to the satisfaction of the Engineer. The test with this calibrated equipment shall be performed in presence of the Engineer and the results shall be approved by the Engineer. Shall there be any disagreement on any portion of the test reach and/or results, the test shall be repeated. The Contractor shall not be paid for arrangement(s), performance and any incidentals required for satisfactory performance and/or any remedial measures required to bring the surface conditions within the acceptable limits (≤ 1.50 m/km). The cost shall be deemed to be included in the unit rate for the item.

The test surface shall be cleaned, if required, and shall generally be performed in the both wheel paths of the lanes/carriageway or as per directions of the Engineer. The IRI shall have limiting values as shown in Table 20.6. These values are in meters per kilometre computed on basis of 200 metre

section. The Contractor is required to make the surface conditions within the acceptable limits. The price adjustment, if requested in writing by the contractor and approved by the Engineer, for any particular section, for item unit rates approved in bid shall be adjusted/evaluated in each section as per limiting values shown in the Table 20.6.

Table 20.6, Price Adjustment of Wearing Course w.r.t IRI Values

IRI, m/km	Deduction (%age)
≤ 1.50	0
1.50 – 1.90	10
1.90 – 2.30	15
2.30 – 2.70	25
> 2.70	100

20.3.3 Pavement Surface Tolerances

The allowable tolerances shall be according to limits as included in Table 20.7.

Table 20.7, Allowable Tolerances for Asphaltic Wearing Course

Sr. No.	Description	Range, mm
1	Thickness	± 3
2	Level	± 3
3	5-metre Straight Edge	5
4	Cross Fall	± 0.20
5	Longitudinal Grade in 30-metre	± 0.10

20.4 SAMPLING AND TESTING REQUIREMENT

The sampling and testing requirement for asphaltic base shall be as included in Table 20.8.

Table 20.8, Sampling & Testing Requirement of Wearing Course

Sr. No.	Test	Designation	Frequency
Coarse Aggregate			
1	Gradation	AASHTO T-27	1 per 1000 cubic metre
2	Abrasion	AASHTO T-96	3 per source and 1 per 5000 cubic metre
3	Sodium Sulphate Soundness	AASHTO T-104	3 per source and 1 per 5000 cubic metre
4	Stripping	AASHTO T-182	3 per source and 1 per 5000 cubic metre
5	Fractured Faces	Visual	3 per source and as required

Sr. No.	Test	Designation	Frequency
			based on visual observation
6	Flat & Elongated Particles	Visual	3 per source and as required based on visual observation
7	Specific Gravity & Absorption	AASHTO T-85	4 per source for each size in hot bins of Asphalt Plant
	Fine Aggregate		
8	Sand Equivalent or Plasticity Index	AASHTO T-176 AASHTO T-89 & T-90	3 per source and as required based on visual observation 2 per 1000 cubic metre
9	Specific Gravity	AASHTO T-84	2 per source
10	Friable Particles	AASHTO T-112	1 per 5000 cubic metre
	Asphalt Cement		
11	Specific Gravity	AASHTO T-228	2 per shipment
12	Penetration	AASHTO T-49	3 per week of plant operation (samples taken from heating tank at staggered intervals)
	Premix Asphalt		
13	Extraction	AASHTO T-164	2 per day's production
14	Gradation	AASHTO T-30	
15	Flow	AASHTO T-245	
16	Stability	AASHTO T-245	
17	Bulk Sp. Gravity	AASHTO T-166	
18	Loss Stability	AASHTO T-245	
	Mixture Compacted in Place		
19	Thickness	AASHTO T-230	1 per layer @ 100 metre interval per lane
20	Compaction	AASHTO T-230 ASTM D2950	1 per layer @ 100 metre interval per lane

20.5 MEASUREMENT AND PAYMENT

20.5.1 Measurement

The quantities of Asphaltic wearing course shall be measured by area in square foot or square metre (whichever is included in Bill of Quantities) laid and compacted in place. Measurements shall be based on the dimension as shown on Drawings or as otherwise directed or authorized by the Engineer. A tolerance of $\pm$ three (3) mm shall be allowed in compacted thickness of wearing course. However, any asphalt in excess of 3 mm shall not be paid and any layer deficient by more than 3 mm but not exceeding 5 mm shall be paid as per SECTION-20.5.2 of this specification.

The quantity of bitumen material used is included in the asphalt concrete mixture and will not be measured separately.

Quantities of Bitumen or asphaltic concrete wasted or remaining on hand after completion of the work shall not be measured or paid for.

20.5.2 Payment

- a) The quantity determined as provided above shall be paid for at the contract unit price respectively for each of the particular pay items shown in the Bill of Quantities, which prices and payment shall constitute full compensation for all the costs necessary for the proper completion of the work prescribed in this item. Asphalt additive or anti-stripping agent, if allowed and used to meet with JMF requirement shall not be paid directly, payment shall be deemed to be included in the respective pay items of Asphaltic wearing course.
- b) If the thickness determined as per SECTION-20.5.1 of this specification is deficient by more than three (3) mm, but not more than five (5) mm, payment will be made at an adjusted price as specified in Table 20.9.

Table 20.9, Reduction in Contract Price of Asphalt Concrete

Sr. No.	Deficiency in Thickness as Determined by Cores	Proportional Rate of Contract Price Allowed
1	0.0 mm to 3.0 mm	100%
3	3.01 mm to 5.0 mm	80%

When wearing course is more than five (5) mm deficient in thickness, the Contractor shall remove such deficient areas and replace them with wearing course of an approved quality and thickness. Replacing or overlaying due to deficient asphalt thickness shall be done in full asphalted width of roadway and for a minimum 100 meters length with smooth transition as approved by the Engineer. The Contractor will receive no compensation for the above additional work.

PART - 5: ANCILLARY WORKS FOR ROADS

SECTION - 21: CONCRETE KERB STONE

21.1 SCOPE OF WORK

This work shall consist of precast concrete kerb, gutter, channel, or combination of kerb and gutter or channel; constructed of the following materials and in accordance with the specifications at the location and of the form, dimensions and designs shown on the Drawings or as directed by the Engineer.

21.2 MATERIAL REQUIREMENTS

The concrete for cast in place concrete kerbs, gutters and channels shall be Class 'C' as indicated on the Drawings and shall conform to the requirements of that particular class prescribed under Civil Works. An air entraining agent, if required, shall be added during mixing an amount to produce five (5) to eight (8) percent air by volume in the mixed concrete.

Precast concrete kerbing units shall also consist of Class 'C' concrete conforming to the requirement of SECTION-35.5.2 and to lengths, shape and other details shown on the Drawings. Kerbing which shows surface irregularities of more than five (5) mm when checked with three-metre straight edge or surface pits more than fifteen (15) mm in diameter will be rejected.

Forms to hold the concrete shall be built and set-in place as described in these specifications. Forms for at least sixty meters of kerb or combination of kerb and gutter or channels shall be in place and checked for alignment and grade before concrete is placed. Curved sections shall have forms of either wood or metal and shall be accurately shaped to radius of curvature shown on the Drawings.

Expansion joint filler shall be either the performed type conforming to requirement of AASHTO-M 153 or shall be precast fibre board packing.

Joint filler shall consist of one-part cement and two parts of approved sand with sufficient quantity of water necessary to obtain the required consistency. The mortar shall be used within thirty (30) minutes after preparation.

The Bonding compound when used shall conform to AASHTO M-200.

21.3 CONSTRUCTION REQUIREMENTS

21.3.1 Excavation and Bedding

Excavation shall be made to the required depth as shown on the Drawings. All soft and unsuitable material shall be removed and replaced with a suitable material acceptable to the Engineer.

Bedding shall consist of Class D Concrete conforming to the requirements of Civil Works and dimension shown on the Drawings.

21.3.2 Placing

The precast concrete kerbs shall be set in 1:3 of cement sand mortar to the line, level and grade as shown on the Drawings or as directed by the Engineer.

21.3.3 Joints

Joints between consecutive kerbs shall be three (3) to five (5) mm wide and filled with cement mortar to the full section of the kerb.

21.3.4 Backfilling

After forms has been removed and concrete has been cured as specified, the excavation of kerbs, gutters or channels shall be backfilled with suitable earth or granular material tamped into place in layers of not more than fifteen (15) cm each until firm and solid.

21.4 MEASUREMENT AND PAYMENT

21.4.1 Measurement

The unit of measurement for concrete kerb, gutter, or combination of kerb and gutter, channel, or extruded kerbs and channels shall be measured by the linear metre or linear feet (whichever is included in Bill of Quantities) along the front face of the section at the finished grade elevation. Deduction in length will be made for drainage structure installed in the kerbings such as catch basins and drop inlets etc. Measurement will not include any area in excess of those shown on the Drawings except for any area authorised by the Engineer in writing.

21.4.2 Payment

Measured and accepted quantities shall be paid for at the contract unit price per linear metre or linear feet (whichever is included in Bill of Quantities) for each of the particular pay item as shown in the Bill of Quantities which prices and payment shall constitute full compensation for furnishing and placing all materials for concrete, for reinforcing steel if required on the Drawings for expansion Joints, material, form for drainage opening, excavation, backfilling and dumping and disposal of surplus material and for all labour, equipment, tool and incidentals necessary to complete the item.

Payment for expansion joint filler material used in transverse expansion and contraction joints in kerbs and channel shall be understood to be included in the unit price included in Bill of Quantities for the kerbs and channels and shall not be paid separately.

SECTION - 22: PAVEMENT MARKING

22.1 SCOPE OF WORK

This work shall consist of furnishing non reflective or reflective chlorinated rubber based or thermoplastic paint material or retroreflective preformed pavement marking (tape) whichever is shown in the Bill of Quantities, for sampling and packing, for the preparation of the surface and for the application of the paint to the pavement surface all in accordance with these Specifications.

The paint shall be applied in conformance to the size, shape and location of the markings as shown in the Drawings or as instructed by the Engineer in writing.

22.2 CHLORINATED RUBBER PAINT

22.2.1 Material Requirements

A standard and acceptable quality of Chlorinated Rubber based paint shall be used. The paint shall be ready for application and shall be of a smooth quality. The paint shall be homogeneous, well dispersed to a smooth consistency and shall not cake, liver, thicken, curdle, gel, settle badly or show any objectionable properties after period of storage not to exceed six (6) months; Table 22.1.

Table 22.1, Constituents of Chlorinated Rubber Paint

1	White Traffic Paint		
a)	Pigment	Titanium Dioxide Rutile and extenders	100%
b)	Vehicle	Modified Chlorinated Rubber Plasticized and Resin Blend	52±4%
		Solvents	45±4%
		Additives i.e. Flow leveling, adhesion improving agents, anti-oxidants, siccatives etc.	1±3%
c)	Paint Composition	Pigments	55±4% by weight
		Vehicle, Solvent & Additives	45±5% by weight
2	Yellow Traffic Paint		
a)	Pigment	Chrome Yellow and Extenders	100% by weight
b)	Vehicle	Same as for white traffic paint	
c)	Paint	Pigments	55±4% by

	Composition		weight
		Vehicle, Solvent & Additives	45±5% by weight
3	Black Traffic Paint		
a)	Pigment	Chrome Black and Extenders	100% by weight
b)	Vehicle	Same as for white traffic paint	
c)	Paint Composition	Pigments	55±4% by weight
		Vehicle, Solvent & Additives	45±5% by weight

The volatile material shall be of such character that has a minimum solvent action of asphalt, and such that the resins and non-volatile components will be entirely dissolved in the volatile material, and will not precipitate from the solution on standing. The non-volatile material shall be of such quality that it will not darken or become yellow when a thin section is exposed to the sunlight. Other pavement marking paint may be submitted by the Contractor as an alternative to the above, for the approval of the Engineer.

22.2.2 Ballotini for Reflective Road Paint

The grading of ballotini dispersed in the paint shall be as included in Table 22.2.

Table 22.2, Ballotini Grading for Chlorinated Rubber Paint

Sr. No.	Sieve Sizes	Percentage Retained
1	No.12	0
2	No.20	30%
3	No.30	50%
4	No.50	80%
5	No.80	100%

Glass beads shall conform with AASHTO Designation M-247. At least ninety (90) percent glass beads shall be transparent, reasonable spherical and free from flaws.

The proportion of ballotini to paint shall be not less than five hundred (500) grams per litre of paint.

22.2.3 Photometric Requirements for Reflective Road Paint

Other reflective road paints may be considered for use by the Engineer provided they have minimum brightness values at two tenth (0.2) degree and half (0.5) degree divergence expressed as candle power per metre per square metre of surface coating; Table 22.3.

Table 22.3, Photometric Requirements for Chlorinated Rubber Paint

Sr. No.	Description	Angle	White Colour		Yellow Colour	
1	Divergence Angle	-	0.20	0.50	0.20	0.50
2	Incidence Angles	4 degree	237	118	129	75
3	Incidence Angles	40 degree	75	43	43	32

22.2.4 Construction Requirements

Traffic markings shall be applied with approved equipment capable of applying the paint at the specified width and at the specified rate of application. In no case shall the contractor proceed with the work until the equipment, method of application and rate of application as established by a test section have been approved by the Engineer.

The painting of lane markers and traffic strips shall include the cleaning of the pavement surfaces, the application, protection and drying of the paint coatings, the protection of pedestrians, vehicular or other traffic on the pavements, the protection of all parts of the road, structures or appurtenances against disfigurement by spatters, splashes or smirches of paint or of paint materials, and the supplying of all tools, labour and traffic paint necessary for the entire work.

The paint shall not be applied during rain, wet weather, when the air is misty, or when, in the opinion of the Engineer, conditions are otherwise unfavourable for the work. Paint shall not be applied upon damp pavement surfaces, or upon pavements which have absorbed heat sufficient to cause the paint to blister and produce a porous paint film.

The application of paint shall preferably be carried out by a purpose-made machine but where brushes are used only round or oval brushes not exceeding 10 cm. in width will be permitted. The paint, when applied, shall be so applied as to produce a uniform, even coating in close contact with the surface being painted.

Traffic paint shall be applied to the pavement at a rate of one (1) litre to two and half (2.5) square meters or less. Contractor shall provide adequate arrangements that applied paint is not disfigured by moving traffic, till its complete drying and sticking to road surface.

22.3 HOT-APPLIED THERMOPLASTIC ROAD PAINTS

22.3.1 Material Requirements

A) Aggregate

The aggregate shall consist of light-coloured silica sand, calcite, quartz,

calcined flint, or other material approved by the Engineer.

B) Pigment and extender

B.1 White material.

The pigment shall be titanium dioxide complying with the requirements of Type A (anatase) or Type R (rutile) of BS 1851.

B.2 Yellow materials.

Sufficient suitable yellow pigment shall be substituted for all or part of the titanium dioxide to comply with the other requirements of this specification.

B.3 All materials.

The extender shall normally be whiting (i.e. calcium carbonate prepared from natural chalk) complying with the requirements of BS 1795. The manufacturer may substitute lithopone complying with the requirement of BS 296 for any or all of the whiting.

B.4 Binder.

The binder shall consist of synthetic hydrocarbon resin, or, with the approval of the Engineer, gun or wood resin, plasticized with mineral oil.

B.5 Composition of mixture.

The proportions of the constituents of the mixed material as found on analysis shall comply with the requirements of Table 22.4.

Table 22.4, Proportions of Constituents of Thermo-Plastic Paint

Sr. No.	Constituent	Percentage by Mass of Total Mixture	
		Minimum	Maximum
1	Binder (resin and oil)	18	22
2	Pigment	6*	-
3	Pigment and Extender	16	22
4	Ballotini	20**	-
5	Aggregate		-
6	Pigment	78	82
7	Extender and Ballotini		

*For Titanium Di-oxide only, no minimum is specified for yellow material.

**Glass Bead 10% Pre-mixed and 10% to be applied on the surface as drop-on

Where specified, 1% in the case of material to which surface ballotini is to be applied by pressure application.

The grading of the combined aggregate, pigment, extender and ballotini

(where specified) as found on analysis shall comply with the requirements of Table 22.5.

Table 22.5, Grading of Additives in Thermo-Plastic Paint

Sr. No.	Sieve	Percentage by Mass Passing	
		Screeded	Sprayed
1	2.80 mm	100	100
2	1.18 mm	75-95	-
3	600 microns	-	75-95

22.3.2 Sampling and Testing

A) Sampling

For the purpose of carrying out the testing, it is essential that adequate and representative samples be taken in the manner prescribed in specification BS 3262 at following stages.

- At the manufacturer's plant.
- After it has been re-melted by the road application contractor.

B) Testing

The samples shall be prepared and tested in accordance with B.S. Specification 3262 (1976) appendix A to H. The test results shall conform the following properties.

B.1 Softening point.

The softening point shall be not less than 65°C.

B.2 Colour and luminance

- White material**

The luminance factor of white material as delivered by the manufacturer shall be measured in accordance with appendix D and shall not be less than 70 whereas the luminance factor of material obtained from an applicator or melter on site after re-melting measured in accordance with appendix D shall not be less than 65.

- Yellow material.**

The Colour of yellow material shall be approximately BS 381C Colour No. 355, Lemon. The luminance factor of yellow material as delivered by the manufacturer shall be not less than 60 whereas the luminance factor of material obtained from an applicator or melter on site after re-melting measured in accordance with appendix D shall not be less than 55.

B.3 *Heat Stability*

- White Material.

When tested in accordance with appendix E, the luminance factor of white material as measured in accordance with appendix D shall be not less than 65.

- Yellow material.

When tested in accordance with appendix E, the luminance factor of yellow material as measured in accordance with appendix D shall be not less than 55.

B.4 *Flow resistance*

In testing the flow resistance, a cone made and tested in accordance with appendix F, shall not slump by more than 25%.

B.5 *Skid resistance.*

When tested in accordance with appendix G, the skid resistance of a newly laid marking prepared under the stated conditions shall be not less than 45.

22.3.3 Manufacturing, Packing and Storing of Paint

A) Manufacturing

The paint shall be produced in a plant owned and operated by the manufacturer following a process which has been used by the manufacturer for at least five (5) years to produce paint. The equipment for mixing and grinding shall be clean, modern, and in good condition.

B) Packing

- The material shall be supplied in sealed containers which do not contaminate the contents and which protect them from contamination.
- Each container shall be clearly and indelibly marked with the manufacturer's name, Batch number, date of manufacture, reflectorisation (if applicable), colour, chemical type of binder and maximum safe heating temperature; container weight shall be not less than 25 kg or more than 100 kg.

C) Storing

The material shall be stored in accordance with the manufacturer's instructions and any material that is in damaged containers of which the seal has been broken, shall not be used.

22.3.4 Certification

The Contractor shall furnish a certificate from manufacturer that the material he proposes to use has the required properties, stating the maximum and minimum proportions and grading of the constituents, the acid value of the binder, the setting time, the maximum safe heating temperature, the temperature range of the apparatus and the proposed method of laying.

22.3.5 Application of Material to the Road.

A) Preparation of site

The thermoplastic paint shall only be applied to surfaces, which are clean and dry. Immediately before the application of paint, the surface shall be cleaned with mechanical broom, compressed air or other approved means to remove surplus asphalt, oils, mud, dust and other loose or adhered material. The material shall not be applied if the road surface is at a temperature of less than 5°C.

B) Preparation of material on site

The material shall be melted in accordance with the manufacturer's instructions in a heater fitted with a mechanical stirrer to give a smooth consistency to the thermoplastic material and such that local overheating will be avoided. The temperature of the mass shall be within the range specified by the manufacturer, and shall on no account be allowed to exceed the maximum temperature stated by the manufacturer. The molten material shall be used as expeditiously as possible, and for thermoplastic material, which has natural resin binders or is otherwise sensitive to prolonged heating, the material shall not be maintained in a molten condition for more than 4 hours.

- After transfer to the laying apparatus, the material shall be maintained within the temperature range specified by the manufacturer and stirred to maintain the right consistency for laying.
- On concrete carriageway, a tack coat compatible with the marking material shall be applied in accordance with the manufacturer's instructions prior to the application of thermoplastic material.

C) Laying

- a) Carriageway centre lines, lane lines and edge lines shall be laid to a regular alignment by self-propelled machine. Other markings may be laid by hand, hand propelled machine or self-propelled machine as approved by the Engineer;
- b) The road surface shall be dry and free from loose detritus, mud and other extraneous matter. Where old paint or thermoplastic materials are present, the Contractor shall be responsible, if required, for removal of that paint to make the surface suitable and acceptable

to the Engineer.

- c) The drying time shall be not more than 10 minutes in the laboratory test (AASHTO designation M 249);
- d) The spray plastic shall be used at temperatures between 211-225°C;
- e) In addition, the glass beads included in the material a further quantity of glass beads shall be sprayed onto the hot spray plastic line at the time of application and shall be approximately 400-500 grams per square metre. The application should be pressurized; and
- f) The finished lines shall be free from ruggedness on sides and ends and be in true plane with the general alignment of the carriageway. The upper surface of the lines shall be level uniform and free from streaks and cracks.

D) Reflectorization by surface application

When surface application of ballotini is required, additional ballotini (400 g/m² to 500 g/m² from the machine) shall be applied by pressure concurrently with the laying of the line with sufficient velocity to ensure retention in the surface of the line. The ballotini so sprayed shall give uniform cover and immediate reflectivity over the whole surface of the marking.

Ballotini dispensed on the surface of the markings shall conform to the grading as included in Table 22.6.

Table 22.6, Ballotini Grading for Thermo-Plastic Paint

Sr. No.	Sieve Size	Percentage by Mass Passing
1	1.7 mm	100
2	600 microns	80-100
3	425 microns	45-100
4	300 microns	10-45
5	212 microns	0-25
6	75 microns	0-5

Not less than 90%, by mass of the ballotini, shall be of transparent glass, spherical in shape and not more than ten (10) percent shall be ovate in shape or have other flaws. The ballotini shall be made of soda glass.

E) Thickness

Unless otherwise approved by the Engineer, the material shall be laid to the following thicknesses.

- Sprayed lines other than yellow. Not less than 1.5 mm.
- Sprayed yellow edge lines not less than 0.8 mm.

The minimum thicknesses specified are exclusive of surface applied ballotini. The method of thickness measurement shall be in accordance with appendix H of BS 3262 (1976).

22.3.6 Trial Section

In no case shall the contractor proceed with the work until the equipment, method of application and rate of application conforming the required thickness (as established by a test section) have been approved by the Engineer.

22.4 CEMENTITIOUS MARKING COMPOUND

Cementitious marking compound shall be used for Concrete, Surface Dressing and Bitumen to provide enhanced night and wet, weather visibility. This compound will be applied at following locations:

- Kerbs - Pavements and car park areas.
- Roundabout - vertical and sloping faces.
- Traffic Islands - vertical edges and bull noses, etc.
- Traffic Dividers - black and white chevrons.
- Concrete wall and faces - on high-speed intersections and traffic merging.

22.5 MEASUREMENT AND PAYMENT

22.5.1 Measurement

The quantity of non-reflective or reflective chlorinated rubber based or thermoplastic pavement marking paint, shall be the no. of linear meters or linear feet (whichever is included in Bill of Quantities) of painted traffic line for the specified width as indicated in Bill of Quantities or as shown in the Drawings and/or directed by the Engineer in place, completed and accepted.

The arrows etc. shall be measured square meters or linear feet (whichever is included in Bill of Quantities) for indicative items as included in the Bill of Quantities.

The measurement shall be made of painted areas, completed and accepted. No measurement shall be made of unauthorized areas. Paint that is applied in un-authorized areas shall be completely removed from the surface of the road to the satisfaction of the Engineer and at Contractor's expense.

22.5.2 Payment

The quantities measured as determined above shall be paid for at the Contract unit price respectively for the pay items included in the Bill of

Quantities, which price and payment shall constitute full compensation for furnishing and placing all materials including sampling, packing and testing at approved laboratory. The cost shall also include the preparation of the surface, and for all other costs necessary to complete the work as prescribed in this item.

SECTION - 23: PAVEMENT STUDS

23.1 SCOPE OF WORK

This item shall consist of furnishing and installing reflectorized pavement studs set into the travelled way of the type in accordance with the specifications and at the locations shown on the Drawings or as directed by the Engineer.

23.2 MATERIAL REQUIREMENTS

23.2.1 Reflectorized Studs

Reflectorized Studs shall be "cat-eyes" either the 'Flush Surface' type or 'Raised Profile' type having the following characteristics.

A) 'Flush Surface' Type

The 'Flush Surface' reflector shall be the short base type having a maximum base area of 18 cm x 14 cm or as shown on the Drawings.

The base shall be formed in cast-iron with adequate webbing to ensure a firm key to the road when installed.

The pad shall be highly resilient and durable rubber reinforced with canvas and shall have an anticipated life of at least five (5) years. The pad shall be so designed as to produce a self-whipping action of the reflector when depressed.

The reflectors shall be made of impact and abrasion resisting glass and shall be hermetically sealed into a copper socket.

B) 'Raised Profile' Type

The 'Raised Profile' reflectors shall consist of an acrylic plastic shell filled with an adherent epoxy compound moulded from methyl methacrylate into the shape of a shallow frustum of a pyramid having base dimension of approximately 10 cm x 10 cm and thickness not more than two (2) cm or as shown on the Drawings.

The shell shall contain one or two prismatic reflector each inclined at an angle of thirty (30) degree to the horizontal and having an area not less than twenty (20) square cm or as indicated on the Drawings.

The reflectors shall attain the following standards for their photometric and physical qualities:

B.1 Photometric Requirements

The reflectors shall have the minimum Specific Intensity values (S.I) expressed as candle power per foot candle of illumination at the

reflector on a plane perpendicular to the incident light as included in Table 23.1

Table 23.1, Minimum Specific Intensity Values for Reflectors

Property	Colour (S.I)		
	Crystal	Yellow	Red
Divergence Angle	0.20	0.20	0.20
Incidence Angle (in degree)			
0	3.00	1.80	0.75
20	1.20	0.72	0.30

The reflector for testing shall be located with the centre of the reflecting face at a distance of one and half (1.5) m from a uniformly bright light source having an effective diameter of half (0.5) centimetre.

The width of the photocell shall be 1.27 cm and shall be shielded from stray light. The distance from the centres of the light source and photocell shall be 0.53 cm.

Failure of more than four (4) % of the reflecting faces shall be cause for rejection of the lot.

B.2 Strength Requirement

The reflectors shall support a vertical load of 1000 kg when tested in the following manner.

A reflector shall be centred horizontally over the open end of a vertically positioned hollow metal cylinder seventy-five (75) mm internal diameter, twenty-five (25) mm high and wall thickness of six (6) mm. The load shall be applied to the top of the reflector through a six (6) mm diameter by six (6) mm high metal plug centred on top of the reflector.

Failure shall constitute either breakage or significant deformation of the marker at any load less than one thousand (1000) kg.

23.2.2 Adhesive

When 'Raised Profile' type of reflectors are used, a two-part adhesive shall be applied to the stud for bonding to the pavement surface. The adhesive is having the ingredients as included in Table 23.2.

Table 23.2, Bonding Material for Raised Profile Studs

Sr. No.	Ingredients	Kg/Litre
Package A		
1	Epoxy Resin	0.94
2	Titanium Dioxide	0.07
3	Colloidal Silica	0.05
4	Talc	0.345
Package B		
5	Modified Asphaltic Amine Hardener (Reinhold 2611)	0.24
6	Modified Asphaltic Amine Hardener (Reinhold 2613)	0.472
7	Carbon Black	0.0022
8	Colloidal Silica	0.04
9	Talc	0.65

Equal volumes of Package A & B should be mixed together until a uniform colour is obtained. No more than one quart of adhesive shall be prepared at one time.

23.2.3 Cement Mortar

Cement mortar shall consist of one (1) part Portland cement to three (3) parts of fine aggregates.

23.3 CONSTRUCTION REQUIREMENTS

23.3.1 Flush Surface Type

The stud shall be installed into the pavement in accordance with the manufacturer's instructions but shall also comply with the following requirements:

Cavities in the pavement shall be clearly cut to the dimension of the pavement stud and shall allow a clearance of one (1) cm around the stud base. The longitudinal centre line axis of the cavity shall be the same as that required for the pavement stud when laid to correct line and direction.

The walls of the cavity shall be splayed back at an angle of approximately thirty (30) degree to the vertical to facilitate a "dove-tail" joint after the mortar has set.

The bottom of the cavity shall be levelled with asphalt concrete prior to placing the stud base, which shall be pounded into position with Pounder Foot attached to a pneumatic drill.

The depth of the cavity shall be such that when the stud base and reflectors

have been installed the elevation of the floor of the lens socket shall not be greater than two (2) mm or less than one (1) mm above the pavement surface.

The stud shall be grouted into position with asphalt concrete containing fine aggregate only or with a cement mortar as described in SECTION-23.2.3 above when the studs are installed into a cement concrete pavement.

23.3.2 Raised Profile Type

The pavement studs shall be installed in accordance with the manufacturer's instructions or to the requirements of the Engineer.

23.4 MEASUREMENT AND PAYMENT

23.4.1 Measurement

The quantity of reflectorized pavement studs to be paid for shall be the number of 'Flushed Surface' or 'Raised Profile' type provided and installed as mentioned above.

23.4.2 Payment

The quantities measured as described above shall be paid for at the contract unit price respectively for the pay items listed below and shown in the Bill of Quantities, which payment shall constitute full compensation for furnishing and placing all materials, excavating cavities, preparation of surfaces, applying adhesive and mortar, for all labour, equipment, tools and incidentals necessary to complete the item.

SECTION - 24: SIGN BOARDS

24.1 SCOPE OF WORK

This work shall comprise furnishing and installing traffic signs, permanent safety devices and post assemblies in accordance with these specifications and to the details shown on the Drawings. All sign faces and lettering shall be in accordance with NHA/NTRC sign standards or as shown on Drawings. Prior to manufacture and fabrication of the signs the contractor shall submit to the Engineer for approval detailed Drawings showing letter sizes, traffic symbols and sign layout. The permanent safety devices shall consist of road posts and hazard markers and will be provided as per specifications, Drawings or as directed by the Engineer.

24.2 MATERIAL REQUIREMENTS

24.2.1 Sign Panels

Sign panels for regulatory, warning and informatory signs shall be manufactured from aluminium alloy conforming to ASTM B 209, alloy 6061-T6 or 5052 - H38 plates of three (3) mm thickness as shown on the Drawings.

The blanks shall be free from laminations, blisters, open seams, pits, holes, or other defects that may affect their appearance or use. The thickness shall be uniform and the blank commercially flat. Perform shearing, cutting and punching before preparing the blanks for application of reflective material.

The blanks shall be cleaned, degreased, and chromate or otherwise properly prepared according to methods recommended by the sheeting manufacturer.

24.2.2 Reflective Sheeting

Reflective sheeting used on road sign made of flexible white or coloured, wide angle retroreflective sheeting (herein after called sheeting), and related processing materials designed to enhance night-time visibility. The sheeting shall consist of optical elements adhered to a synthetic resin and encapsulated by a flexible transparent plastic that has a smooth outer surface.

The sheeting shall have either a precoated pressure sensitive adhesive or a tack-free adhesive activated by heat applied in a heat vacuum applicator in a manner recommended by the sheeting manufacturer. Both adhesive classes shall be protected by an easily removable liner.

The manufacturer of the sheeting being offered shall furnish the process inks, clears and thinners produced by the sheeting manufacturer recommended for and compatible with the sheeting to meet the performance requirements

of this specification and shall further be responsible for technical assistance in the use of these inks or alternatively sheeting can be used on sheeting.

The sheeting manufacturer must provide documented evidence to the satisfaction of the Engineer that representative production materials of the type to be supplied has been used successfully in a substantial traffic signing program in similar climatic conditions for at least three years.

A) Colour Requirements.

Colour shall be specified and conform to the requirements of Table 24.1.

B) Coefficient of Retroreflection.

The coefficients of retroreflection shall conform to the minimum requirements of Table 24.2.

Table 24.1, Colour Specifications Limits* and Reference Standards

Sr. No.	Colour	X	Y	X	Y	X	Y	X	Y	Reflectance Limit (Y)		Munsell Paper**
										Min.	Max.	
1	White	0.303	0.287	0.368	0.353	0.340	0.380	0.274	0.316	27	-	5PB 7/1
2	Yellow	0.498	0.412	0.557	0.442	0.479	0.520	0.438	0.472	15	40	1.25Y 6/12
3	Red	0.613	0.297	0.708	0.292	0.636	0.364	0.558	0.352	2.5	11	7.5R 3/12
4	Blue	0.144	0.030	0.244	0.202	0.190	0.247	0.066	0.208	1	10	5.8PB 1.32/6.8
5	Orange	0.550	0.360	0.630	0.370	0.581	0.418	0.516	0.394	14	30	2.5YR 5.5/14
6	Brown	0.430	0.340	0.430	0.390	0.550	0.450	0.610	0.390	3	9	5YR 3/8
7	Green	0.030	0.380	0.166	0.346	0.286	0.429	0.201	0.776	3	8	10G 3/8

* The four pairs of chromaticity coordinates determine the acceptable colour in terms of the CIE 1931 standard colourimetric system measured with standard illumination Source C.

** Available from Munsell Colour Company, 2441 Calvert Street, Baltimore, Maryland 21218. Catalog No. MCP-90040.

Table 24.2, Minimum Coefficient of Retroreflection

Sr. No.	Observation Angle	Entrance Angle	White	Red	Yellow	Green	Blue	Brown	Orange
1	0.2°	-4°	250	45	170	45	20	12	100
2	0.2°	+30°	150	25	100	25	11	8.5	60
3	0.5°	-4°	95	15	62	15	7.5	5	30
4	0.5°	+30°	65	10	45	10	5	3.5	25

Retroreflection in Candelas per Foot Candle per Square Foot.

For screen printed transparent coloured areas on white sheeting, the coefficients of retroreflection shall not be less than 70% of the values for corresponding colour in the above table.

The sheeting manufacturer shall provide a test report from British Standards Institution (BSI) or any internationally recognised laboratory stating that the sheeting meets the requirements according to BSI 873 Part 6. or FP 92 of FHWA.

The brightness of the reflective sheeting totally wet by rain, shall be at least ninety (90) % of the above values.

The reflective sheeting shall be sufficiently flexible as to permit application over and adhesion to a moderately embossed surface. It shall not show damage when bent ninety (90) degree over a fifty (50) mm diameter mandrill.

The sheeting shall show no cracking or reduction in reflection after being subjected to the dropping of a twenty-five (25) mm diameter steel ball from a height of two (2) meters onto its surface.

For heat activated material the adhesive shall permit the reflective sheeting to adhere securely forty-eight (48) hours after application, at temperatures of up to ninety (90) degree Centigrade.

The reflective material shall be weather-resistant and following cleaning, shall show no definite fading, darkening, cracking, blistering or peeling and not less than seventy-five (75) % of the specified wet or dry minimum brightness values when exposed to weathering for five (5) years.

C) Performance Requirements & Obligation

The sign manufacturer shall submit a certificate from the sheeting manufacturer stating that the sheeting used for finished retroreflective signs meets all requirements listed herein.

Sheetings processed and applied to sign blank materials in accordance with sheeting manufacturer's recommendation, shall perform effectively for the number of years stated in Table III of this specification. The retroreflective sheeting will be considered unsatisfactory if it has deteriorated due to natural causes to the extent that: (1) the sign is ineffective for its intended purpose when viewed from a moving vehicle under normal day and night driving conditions; or (2) the coefficient of retroreflection is less than the minimum specified for that sheeting during that period listed in Table 24.3.

Table 24.3, Minimum Coefficient of Retroreflection after 7 & 10 Years

Sr. No.	Sheeting Colour	Minimum Coefficient of Retroreflection (7 Years)	Minimum Coefficient of Retroreflection (10 Years)
1	White	212	200
2	Yellow	144	136
3	Green	38	36
4	Red	38	36
5	Blue	17	16
6	Brown	10	9

Retroreflection in Candela per Foot Candle per Square Foot with Observation Angle as 0.2° and Entrance Angle as -4°.

For screen printed transparent coloured areas on white sheeting, the coefficients of retroreflection shall not be less than 50% of the values for the corresponding colour in the above table.

All measurements shall be made after sign cleaning according to sheeting manufacturer's recommendations.

Where it can be shown that retroreflective traffic signs supplied and used according to the sheeting manufacturer's recommendations have not met the above performance requirements, the sheeting manufacturer shall cover restoration costs as follows for sheetings shown to be unsatisfactory during.

- The entire seven years the sign manufacturer and sheeting manufacturer will replace the sheeting required to restore the sign surface to its original effectiveness.
- In addition, during the first five years sign manufacturer and sheeting manufacturer will cover the cost of restoring the sign surface to its original effectiveness at no cost to the NHA for materials and labour.

Samples of the reflective sheeting shall be approved by the Engineer prior to the Contractor placing his order.

24.2.3 Metal Posts

Wide flange of 10 x 10 centimetres metal posts shall be fabricated from structural steel conforming to the Specifications of ASTM A 283 Grade D.

In lieu of wide flange steel posts the Contractor may use tubular steel posts of minimum internal and external diameters of sixty-three (63) mm and seventy-five (75) mm respectively conforming to the specifications of ASTM A 501.

All posts shall be thoroughly cleaned, free from grease, scale and rust, and shall be given one coat of rust inhibitive priming paint and two coats of grey

paint. Length of the posts shall be such that their top flushes with the top of the sign panel, whereas bottom of sign panel is at least hundred and eighty (180) centimetres above shoulder level.

24.2.4 Plates

- a. Plates shall be non-porous, smooth, flat, rigid, weather proof and shall not rust or deteriorate otherwise.

It shall be so cut that there are no sharp edges and that the corners are rounded off to a radius of thirty-seven and half (37.5) mm. Any trade mark or other printing shall be carefully removed with liquid thinner.

- b. The High Intensity Grade sheeting for the background should cover the whole area of the sign plate.
- c. Prior to application of the High Intensity Grade reflective sheeting, the sign plate shall be cleaned and shall be wax-free. They shall be degreased by vapour or by alkaline immersion and etched by scrubbing with abrasive cleaner. The plate shall be rinsed thoroughly and dried with hot air before applying the sheets.
- d. The sheeting after application to the sign base shall not come off the edges, which shall be sealed, nor shall it peel off nor warp. The surface shall be smooth and free from any bubbles, pimples, edge chipping or edge shattering. It shall be washable and weather-proof.

24.2.5 Nuts and Bolts

All Nuts and bolts and metal washers shall be of heavily galvanized quality ten (10) mm dia (G.I.) or aluminium alloy. The bolt heads to be such that they do not protrude out too much nor show very much on the front face of the plate. The heads should be flush with the plate face and covered with sheeting galvanised according to ASTM A 153.

24.2.6 Rubber Washer

All rubber washers shall have thick walls and shall not get dry and brittle when exposed to weather at the site after they are in position during the life of the sign.

24.2.7 Caps over the pipes

These can be of heavy plastic or of aluminium well fitted so that they cannot be removed; any good adhesive can be used.

24.2.8 General

- a. Very large signs need not be made of one piece; in that case extended Aluminium panels shall be used or the various pieces of

sheet shall be joined by angle-irons in anti-corodal materials, and, if necessary, with connecting cross pieces in order to ensure the solidity of the joint and with slanting struts embedded in the concrete as directed by the Engineer.

- b. All the nuts and bolts and metal washers must be heavily galvanized, or may be of stainless steel of high quality.
- c. Relevant holes to receive ten (10) mm bolts shall be drilled into the pipes and the plates and not punched. These to be drilled through the plates before the application of scotchlite.
- d. After the plates are fixed with nuts and bolts, the nuts shall be TACK WELDED to the bolts against pilferage.

24.2.9 Concrete Foundation Blocks

The concrete for the foundation blocks shall be in situ Class C in accordance with SECTION-35.5.2 and shall of the size 450 x 450 x 650 mm for category 1 & 2 and 600 x 600 x 750 mm for category 3 or as shown in the Drawings or as directed by the Engineer.

In case precast concrete foundations are used, these shall also be of the Class C and of the sizes as shown on the Drawings and/or as directed by the Engineer.

24.2.10 Road Posts and Hazard Markers

The road posts and hazard markers used as permanent safety devices shall conform fully with the requirements of the statutory instruments, current British standards and chapter four (4) of the Traffic signs manual. The safety devices shall consist of delineators and detours of verge master, flex master, edge master, passing place post, and chevreflex etc. and will be manufactured from highly durable tough plastic material withstanding vehicular impact. These shall be of High Intensity Grade reflective sheeting for maximum visibility by both day and night and consequently be resistant to impact, damage and vandalism.

24.3 CONSTRUCTION REQUIREMENTS

24.3.1 Excavation and Backfilling

Holes shall be excavated to the required depth of the bottom of the concrete foundation as shown on the Drawing.

Backfilling shall be carried out by using the surplus excavated material if approved by the Engineer and shall be compacted in layers not exceeding fifteen (15) cm in depth.

Surplus excavated material shall be disposed of by the Contractor as directed by the Engineer.

Concrete shall be placed against the undisturbed excavated faces, except that the top fifteen (15) centimetres of each footing shall be formed. Forming of the entire footing will not be permitted unless approved by the Engineer. Concrete shall be thoroughly rodded and spaded so as to eliminate all voids. Tops of footings shall be finished with a wood float and all exposed edges shall be rounded with an edger.

Backfill shall be thoroughly compacted by mechanical tampers, and care taken to prevent damage to the finished concrete. Backfill shall be brought up level with the finished ground line. Pipe post bases and/or posts set in concrete shall be firmly supported, plumb, vertical and at the proper elevation.

24.3.2 Erection of Posts

The posts shall be erected vertically in position inside the formwork of the foundation block prior to the placing of the concrete and shall be adequately supported by bracing to prevent movement of the post during the setting process of the concrete. The posts shall be located at the positions shown on the Drawings.

24.3.3 Sign Panel Installation

Sign panels shall be installed by the Contractor in accordance with the details shown on the Drawings. Any chipping or bending of the sign panels shall be considered as sufficient cause to require replacement of the panels at the Contractor's expense.

The exposed portion of the fastening hardware on the face of the sign shall be painted with enamels matching the background colour.

All newly erected traffic road signs shall be covered with burlap or other material until their uncovering is ordered by the Engineer

24.3.4 Categories of Signs

Traffic road signs shall be of three categories according to type of construction

A) Warning Signs

Constructed with single post and sign of equilateral triangle shape, as shown in Drawings, category 1.

B) Regulatory Signs

Constructed with single post and sign of circular shape, as shown in the Drawings, category

C) Informatory Signs

These signs shall be rectangular in shape and constructed with one, two or three numbers of posts or as shown on the Drawings. Dimensions may vary

according to the requirements.

D) Additional panel

If any panel is required to be installed, it shall be of the sizes 60x30 cm or 90x30 cm.

24.3.5 Installation of Safety Devices

Safety devices comprising of road posts, delineators of various types, fixed / portable safety barriers and hazard markers e.g. verge-master, flex-master chevreflex, bigmax, edgemaster and passing place post and other etc., shall be installed in accordance with the techniques and methods laid down in the manufacturer's manual or guide and in conformity to the line and level and locations shown on the Drawings or as directed by the Engineer to ensure maximum visibility and safety, even in adverse weather conditions. These shall be constructed strictly with the specifications and full assistance by the manufacturer for installation with precision. These safety devices shall be used as delineators at sharp curves of highways verges, high embankments, culverts, bridges, as a visual and physical deterrent for prohibiting car parking on grass verges and protecting kerb-side areas on public and private roads.

24.3.6 Sign faces

A) Design

All sign faces shall be of the type, colour, design and size as shown in the Drawings. Size and spacing of letters shall be as included in Table 24.4.

Table 24.4, Size & Spacing of Letters on Sign Boards

Sr. No.	Description	Size
1	The Urdu writing shall be in "Persian" character	
2	The Urdu and English writing shall be about the same in length, width and spacing.	
3	English letters are to be in Smalls except the first letter of the word, which is to be in Capital.	
4	Height of Capital letters	21 cm
5	Height of Small letters	17 cm
6	Stroke Width and Width of border	3.5 cm
7	Space between words and border (at least)	5 cm
8	Space between Words	5 cm
9	Space one line will occupy	4 cm
10	Space between digits of numerals	4 cm
11	Height of numerals same as capital letters	23 cm
12	Space between lines (at least)	5 cm

Sr. No.	Description	Size
13	Height of letter for km	'K' 23 cm 'm' 8 cm
14	Width of letters for km including spacing	'K' 8 cm 'm' 9.6 cm
15	Width of dividing line	2 cm
16	The size and spacing for Urdu letter and Words will generally conform to the dimensions shown above for English letters.	
17	The spelling of place names in Urdu and in English shall be as written in the Survey of Pakistan, maps.	

B) Shop Drawings

The contractor shall submit to the Engineer for approval, three (3) copies of drawings for all special sign faces and all sign faces bearing messages, showing the design and/or arrangement and spacing of both the Urdu and English sign messages. Official town names and their spelling shall be as provided by the Engineer. Size and style of lettering shall be as shown on the Drawings or as otherwise approved by the Engineer.

24.3.7 Storage of Signs

Signs delivered for use on a project shall be stored off ground and under cover in a manner approved by the Engineer. Any signs damaged, discoloured or defaced during transportation, storage or erection shall be rejected.

The rear sign face of all signs shall be painted with two (2) coats priming paint pigmented with chromates of chromes (excluding lead chromes) plus two (2) coats of weather-resisting dull silver gray paint. Where connection of large aluminium sheet signs to a steel stiffening frame is required, the studs or screws

24.3.8 Painting

The rear sign face of all signs shall be painted with two (2) coats priming paint pigmented with chromates of chromes (excluding lead chromes) plus two (2) coats of weather-resisting dull silver-grey paint. Where connection of large aluminium sheet signs to a steel stiffening frame is required, the studs or screws, bolts and washers shall be painted to properly match the colour of the surrounding material.

24.3.9 Placing and Orientation

The Engineer will approve and mark the longitudinal location of each sign the working drawings submitted by the Contractor.

The sign shall be laterally positioned from the shoulder or curb as shown on the approved drawings or as directed by the Engineer.

The Contractor shall stake the location of each sign support and shall get its

approval from the Engineer prior to carrying out excavation for foundations. The Engineer may order change in location due to site constraints. No separate payment shall be made to the Contractor on account of such change if the change is made before fixing of the sign support in concrete block.

The Contractor shall be responsible for the proper elevation, off-set, level and orientation of all signs he erects. He shall exercise due care on the preservation of stakes for his and the Engineer's use. If any stakes are lost, damaged, displaced, or removed, the Contractor shall have them reset at his own expense.

Unless otherwise shown on the Drawings all signs shall be erected so that the edge and face of the sign are truly vertical and face is at an angle of ninety-three (93) degrees to the centreline; that is, facing slightly away from the centreline of the lane which the sign serves. Where lanes divide or are on sharp curves, the Contractor shall orient sign faces as indicated on the Drawings and/or as directed by the Engineer so that they will be most effective both in day and night and so as to avoid reflection and glare. All sign supports shall be plumbed.

24.3.10 Sign Posts

Lengths of posts shown on the Drawings for signs are for bidding purposes only. When progress of the Work permits, the Engineer will authorize the location of each sign, with the station and offset distance from the edge of pavement. The Contractor shall be responsible for determination of post lengths to provide the vertical clearance shown on the Drawings. Field cutting of posts shall be performed by sawing.

“Sign Post Support Assemblies” shall be fabricated as detailed on the Drawings. Test specimens for pipe shall be taken at least fifteen (15) centimetres from one end of the pipe, instead of at the ends as specified in ASTM A 53, Grade B. When Galvanizing is specified, assemblies shall be hot-dip galvanized after fabrication. All welds shall be mechanically cleaned before Galvanizing. Galvanized materials on which the Galvanizing has been damaged in transporting, handling, or erection will be rejected or may, with the approval of the Engineer, be repaired in the field by the zinc alloy stick method. Required field welds and adjacent areas on which the Galvanizing has been damaged shall be galvanized by this same method. The zinc alloy stick shall be cast from zinc, tin, and lead in combination with fluxing ingredients. The compound shall be completely liquid at a temperature not lower than two hundred and forty-six (246) degrees C. The area to be re-galvanized shall be thoroughly cleaned, including the removal of slag on welds. The surface shall be heated with an oxyacetylene torch to approximately three hundred and fifteen (315) degrees C, and the alloy stick rubbed over the surface to fix a deposit. While the alloy is still liquid, a clean

wire brush shall be used to smooth the deposit evenly over the entire area being re-galvanized. If a heavy deposit or build-up is required to match the original coating, more alloy shall be added immediately to the initial bond deposit and spread with a paddle or brush until the required thickness is obtained. Edges of drilled holes shall be coated with commercially available zinc-rich paint. Shop drawings will not be required for pipe posts.

The Contractor shall furnish to the Engineer, fabricators' certifications in triplicate certifying that the material supplied conforms to all of the requirements specified.

24.3.11 Fastening Signs to Sign Posts

Signs shall be fastened to sign supports in accordance with the requirements of the Drawings, the recommendations of the sign manufacturer and to the satisfaction of the Engineer.

After installation of signs on their supports all bolt heads, screw heads, and washers which are exposed on the face of the sign shall be painted. The colour of the paint used shall be as nearly as practical the same as the colour of the background or message area at the point where the bolt, screw, or washer is exposed.

Where steel signs are mounted with aluminium hardware or on steel posts, approved asphalt, nylon, or neoprene insulation shall be installed at all points where dissimilar metals might come in contact.

24.3.12 Erection of Delineators and Marker Posts

Delineators shall be erected at locations shown on the Drawings and set at elevations such that the Delineator reflectors will be at the indicated height above the ground surfaces. Unless otherwise noted in the Drawings or authorized by the Engineer, holes for posts shall be of the depth and size shown on the Drawings. Posts shall be set plumb and to the established lines and grades and shall be encased in concrete class "B" unless otherwise shown on the Drawings. The cost of all excavation and concrete will be considered subsidiary to the bid item (s) for Delineators.

When noted on the Drawings or authorized by the Engineer, the posts shall be erected by driving, either by hand or with approved mechanical devices. The method of driving shall not substantially alter the cross-sectional dimensions of the posts or materially damage the coating. Battered tops will not be permitted. Posts which, in the opinion of the Engineer, are bent or otherwise damaged during or after erection shall be removed from the site and replaced at the Contractor's expense. After driving, the portion of the posts above ground shall be plumb and the posts shall be firm in the ground.

Reflectors shall be attached to the posts as detailed in the Drawings or according to the manufacturer's specifications.

24.4 MEASUREMENT AND PAYMENT

24.4.1 Measurement

The quantities of traffic road signs and safety devices to be paid for shall be measured in number of each category of sign supplied and installed at site as directed by the Engineer.

24.4.2 Payment

The quantities measured as determined above shall be paid for at the contract unit price for the pay items as included in the Bill of Quantities which price and payment shall be full compensation for furnishing all labour, materials, tools, equipment, and for excavation, concreting, backfilling and erection of posts, installation of sign panels and all incidental costs including sheeting/painting necessary to complete the work as prescribed in this item.

SECTION - 25: SPRIGGING AND SODDING

25.1 SCOPE OF WORK

These works shall consist of furnishing top soil and planting sprigs or laying grass sods in accordance with the specifications, at the location shown on the Drawings, or as required by the Engineer.

25.2 MATERIAL REQUIREMENTS

25.2.1 Top Soil

Top soil furnished by the Contractor shall consist of a natural friable surface soil without admixture of undesirable subsoil, refuse, or foreign materials. It shall be reasonably free from roots, hard clay, coarse gravel, stones larger than 5 cm in diameter, noxious weeds, tall grass, bush sticks, stubble, or other litter, and shall have been cultivated from a healthy growth of crops, grasses, trees or other vegetation that is free draining and non-toxic.

25.2.2 Sprigs

Sprigs shall be healthy living stems (stolons or rhizomes) with attached roots of perennial turf-forming grasses harvested with adhering soil, and obtained from approved sources in the locality of the work where the sod is dense and well rooted. The presence of detrimental materials will be cause for rejection.

25.2.3 Grass Sod

The sod shall consist of a healthy, dense and well rooted growth of living grass.

The grass sod shall be cut into uniform squares approximately 30 cm by 30 cm or in rolls of uniform width of approximately 39 cm and shall have a minimum thickness of 5 cm (excluding grass blades).

25.3 CONSTRUCTION REQUIREMENTS

25.3.1 Top Soil

A) Source of Material

The Contractor shall notify the Engineer at least 5 days before he intends to start top soil stripping operations. After inspection and approval by the Engineer and prior to stripping any top soil, the Contractor shall remove noxious weeds and tall grass, bush roots and stones larger than 5 cm in diameter.

B) Placing Top Soil

The top soil shall be evenly spread on the designated areas to the line and slope if shown on the Drawings and compacted to a depth of not less than 10 cm. Spreading shall not be done when the ground topsoil is excessively

wet, or otherwise in a condition detrimental to the work. The roadway surfaces shall be kept clean during hauling and spreading operations.

After spreading has been completed, large clods, stones, roots, stumps and other loose lying material shall be raked up and removed. Any erosion, irregularities of grade or other incidental damage to the surface of top soil prior to the planting of springs or laying of grass sods shall be required to the Engineer's satisfaction.

25.3.2 Sprigging

A) Harvesting Sprigs

The Contractor shall obtain the Engineer's approval of his source of springs and shall notify the Engineer at least 5 days before the sprigs are to be harvested.

Sprigs that have dried out or are otherwise damaged during harvesting or delivery shall be rejected.

B) Planting Sprigs

Spriggings shall not be done during windy weather, or when the ground is dry, excessively wet, or otherwise un-tillable. If the soil is not moist when the sprigs are being set, water shall be applied until the soil is moist and in a workable condition. One or more of the following methods shall be used, whichever is shown on the Drawings:

- Row sprigging Furrows shall be opened along the approximate contour of slopes at the spacing and depth indicated on the Drawings. Sprigs shall be placed at intervals not exceeding 15 cm in a continuous row in the open furrow, & shall be covered immediately.
- Spot sprigging spot sprigging shall be performed as specified under row sprigging except that, instead of planting in continuous rows, groups of four sprigs or more shall be spaced 50 cm apart in the rows.

25.3.3 Maintenance of Sprigged Areas

The Contractor shall regularly water and maintain sprigged areas in a satisfactory condition for the duration of the contract and until final acceptance of the work by the Engineer.

25.3.4 Sodding

A) Preparation of the Earth Bed

The Surface of the top soil on the area to be sodded shall be loosened and brought to a reasonably fine texture to a depth of approximately 2.5 cm.

B) Placing the Sod

The earth bed upon which the sod is to be placed shall be moistened to the loosened depth, if not naturally sufficiently moist, and the sod shall be placed

thereon within 24 hours after having been cut.

Unless otherwise required, the sod on slopes shall be laid horizontally, beginning at the bottom of the slopes and working upwards. When placing sod scour checks or similar construction, the length of the strips shall be laid at right angles to the direction of flow of the water.

As the sod is being laid, it shall be lightly tamped with suitable wooden tampers, sufficiently to set or press the sod into the underlying soil.

At points where it is anticipated that water may flow over a sodded area, the upper edges of the sod strips (e.g., top of embankment) shall be turned into the soil to be below the adjacent area, and a layer of earth shall be placed over this juncture, and thoroughly compacted.

At the limits of sods areas, the end strips shall be turned in and treated as described above.

C) Staking the Sod

On all slopes which are steeper than one metre vertical to four meters horizontal the sod shall be pegged with stakes, 20-30 cm in length, spaced as needed by the nature of the soil and steepness of slope. Stakes shall be driven into the sod at right angles to the slope until flush with bottom of the grass blades.

D) Top Dressing

After the staking has been completed, the surface shall be cleared of loose sod, excess soil, or other foreign material, whereupon a thin layer of top soil shall be scattered over the sod as a top dressing and the areas shall then be thoroughly moistened by sprinkling with water.

E) Maintenance of Sodded Areas

The Contractor shall regularly water and maintain sodded areas in a satisfactory condition for the duration of the Contract and until final acceptance of the work by the Engineer.

25.4 MEASUREMENT AND PAYMENT

25.4.1 Measurement

The work of sprigging, sodding and top soiling shall each be measured by the square metre or square feet (whichever is included in Bill of Quantities), which has been planted or placed in accordance with these specifications and accepted.

The top soil to be measured for payment shall be that quantity which exceeds the amount in Section - 4: STRIPPING.

25.4.2 Payment

The quantity measured as prescribed above shall be paid for at the contract unit price for the pay items as included in the Bill of Quantities, which payment shall be full compensation for furnishing all materials, water, labour, equipment, tools, transport and all costs necessary to complete the work as prescribed in the above items.

PART - 6: WATER DISTRIBUTION NETWORK

SECTION - 26: EARTH WORK FOR WATER LINES

26.1 SCOPE OF WORK

The work covered by this section of the specifications consists of furnishing all plant, labour, equipment, appliances, and materials and performing all operations in connection with excavation, trenching and back filling (with compaction) for water lines and appurtenances in strict accordance with this section of the specifications and the applicable Drawings, and subject to the terms and conditions of the Contract.

26.2 CLEARING AND GRUBBING

The sites of all excavations shall be cleared of all shrubs, plants, bushes, large roots, rubbish and other surface materials. All such materials shall be removed and disposed of in a manner satisfactory to the Engineer. All trees and shrubbery that are designated by the Engineer to remain shall be adequately protected and preserved in an approved manner.

26.3 EXCAVATION

26.3.1 General

All excavation of whatever substance encountered shall be performed to the depths indicated or as otherwise specified. During excavation, material suitable for backfilling shall be stockpiled in an orderly manner at a sufficient distance from the banks of the excavation to avoid overloading and to prevent sides from caving. All excavated material unsuitable or not require such a manner that street passage is not blocked by excavated material. Grading shall be done as may be necessary to prevent surface water from flowing into trenches or other excavations, and any water accumulated therein shall be removed by pumping or by other approved methods. Unless otherwise indicated or approved by the Engineer, excavation shall be open cut.

26.3.2 Trench Excavation

Unless otherwise directed or permitted by the Engineer not more than 500 feet of any trench in advance of the end of the pipeline already laid shall be opened at any time, unless otherwise directed permitted by the Engineer not more than 1000 feet of any one trench shall be worked on at a time. The banks of the pipe trench shall be as nearly vertical as practicable. Bell holes and depressions for joints shall be dug after the trench bottom has been prepared. The pipe, except for joints, shall rest on the prepared bottom for its length. Bell holes and depressions shall be only of such length, depth, and width as required for properly making the particular type of joints. Stones shall be removed to avoid point bearing. Whenever wet or otherwise unstable

material that is incapable of properly supporting the pipe as determined by the Engineer is encountered in the bottom of the trench, such material shall be removed to the depth required and the trench backfilled to the proper grade with coarse sand, or other suitable approved granular material. Such replacement of unsuitable material will be paid for at the contract unit price for that item of work. Trenches shall be of a depth to provide a maximum cover, over the top of the pipe, of 30 in. from the existing ground surface or finished grade whichever is closer except that trenches for pipe laid in lanes and alleys of narrow travelled way (average width of 8 feet or less between structures) shall be of a depth to provide a minimum cover, over the top of the pipe, of 18 in from the existing ground surface or finished grade whichever is closer.

26.3.3 Excavation for Appurtenances

Excavation for appurtenances shall be sufficient to leave at least 12-inch but not more than 24 in., between the outer surface and the embankment or timber that may be used to hold and protect the banks. Any over depth excavation below such appurtenances that has not been directed by the Engineer, will be considered unauthorized and shall be refilled with compacted sand, gravel or concrete, as directed by the Engineer and at no additional cost to the Employer.

26.3.4 Maintenance of Excavation

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

26.3.5 Removal of Water

The Contractor shall build all drains and do ditching, pumping, well pointing, bailing, and all other work necessary to keep the excavation clear of ground water, sewage and storm water during the progress of the work and until the finished work is safe from injury. All water pumped or drained from the work shall be disposed of in a manner satisfactory to the Engineer and necessary precautions against flooding shall be taken.

26.3.6 Sheet piling and Bracing

If ordinary open cut excavation is not possible or advisable, sheet piling and bracing shall be furnished to the work and to provide working conditions which are safe. The Contractor shall furnish and place all sheet piling, shoring, wall braces, timbers and similar items, necessary for the safety of the work, the general public and adjacent property. Sheet piling shoring and bracing shall be removed as the work progresses and in such a manner as to prevent damage to finished work and adjacent structures and property. As soon as withdrawn, all voids left by the sheet piling and bracing shall be carefully filled

with sand and compacted. The Contractor shall be fully responsible for the safety of work in progress, for the finished work, the workmen, and the public and adjacent property.

26.3.7 Protection of Facilities

Existing subsurface facilities likely to be encountered during the execution of work require special precaution for the protection, such as sewers, drain pipes, water main, conduits and electric cables and the foundations of adjacent structures. The Contractor shall be responsible for the damage of any such facility and shall repair the same at his expense whether or not this facility has been shown on the Drawings.

26.3.8 Surplus Materials

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

26.3.9 Cutting Pavement

In cutting or breaking street surfacing, the Contractor shall not use equipment which will damage the adjacent pavement. Existing paved surfaces shall be cut back beyond the edges of the trenches to form neat square cuts. The road ballast, brick pavement, and other materials shall be placed on one side and shall be preserved for re-instatement when the trench is filled. Wherever necessary or required for the convenience of the public or individual residents, at street crossings and at private driveways, the Contractor shall provide suitable temporary bridges over unfilled excavations. All such bridges shall be maintained in service until backfilling has been completed. The Contractor shall keep the road crossings manned 24 hours per day. During night time, enough red lights shall be provided to warn traffic. If detour is necessary, the Contractor shall make proper detour for the traffic and shall install signs 1 metre by 1.2 metre in size indicating the detour.

26.4 BACKFILLING

- a) The trenches shall not be completely backfilled until all required pressure tests are performed and until the water lines as installed conform to the requirements of specifications. Where in the opinion of the Engineer, damage is likely to result from withdrawing sheeting, shoring; the same shall be left in place and cut off at a level 12-inch below ground surface. Sheeting left in place at the direction of the Engineer will be paid for at the contract unit price/approved rate for that item of work. Trenches shall be backfilled to the ground surface

with selected excavated material or other material that is suitable for proper compaction. Trenches improperly backfilled shall be reopened to the depth required for proper compaction, then refilled and compacted to the specified density. The surface shall be restored to its original or better condition. Pavement and base course disturbed by trenching operations shall be replaced.

- b) Lower Portion of Trench: Backfill material shall be deposited in 6-inch maximum thickness layers and compacted with suitable hand tampers to ninety percent of maximum density until there is a cover of not less than 12-inch over the water lines. The backfill material in this portion of trench shall consist of sandy clay or other approved materials free from stones and humps.
- c) Remainder of Trench: The remainder of the trench shall be backfilled with material that is free from stones larger than 6-inch in any dimension. Backfill material shall be compacted to ninety percent of maximum density.

26.5 BORROW

Where suitable material for backfill is not available in sufficient quantity from required excavations, suitable material shall be obtained from approved sources at the contractor's responsibility. The necessary clearing and grubbing or borrow areas, disposal and burning of debris there from, the developing of sources including any access roads for hauling and the necessary right-of-way, and the satisfactory drainage of the borrow shall be considered as incidental items to borrow excavation.

26.6 GRADING

After the completion of all backfilling operations, the contractor shall grade the work areas to the lines, grades and elevation shown on the Drawings. Finished grading shall not be done until the installation of all water lines has been completed and tested. The top surface after completion shall be "in level" to the adjacent existing surface. Prior to final acceptance, all damage due to settlement shall be repaired by and at the expense of the Contractor.

26.7 TESTING DENSITY OF SOIL IN PLACE

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

26.8 MEASUREMENT AND PAYMENT

26.8.1 Measurement

The measurement shall be made for the actual quantity of the work done in cubic foot or cubic metre (whichever is included in Bill of Quantities). The maximum width of the trenches along with height allowed for payment for various pipe sizes are included in the Drawings.

26.8.2 Payment

The unit rate included in the Bill of Quantities for excavation of trenches for water supply lines shall be considered as full compensation for the work specified in this section and shall include all excavation, backfilling, compacting, constructing and removing all temporary arrangements, pumping and dewatering, disposal of surplus materials, removal of soft soil from bottom of trenches, removing the surface material and all incidentals to complete this work in all respects.

SECTION - 27: HDPE PIPES & FITTINGS

27.1 SCOPE OF WORK

This work shall consist of providing, laying, testing and disinfection of High-Density Polyethylene (HDPE) pipes conforming to ISO 4427, DIN 8074/8075 & PS 3580 with PN-8, 10 & 12.5 (PE 100) and in trenches to correct alignment and grade, as indicated in the drawing and specifications including all other accessories and equipment.

27.2 DEFINITIONS

The following terms shall have the meanings hereby assigned to them except where the Contract clearly renders these meanings inapplicable.

"Pipe" means pipe or pipes, bends, fittings and other specials and includes joints, jointing parts and materials.

"Valves" means gate valves, butterfly valves, air valves and the like and includes jointing materials, operating gear and associated fittings.

"Installation" means removing from storage, loading, hauling, handling, placing, fixing, jointing in position and testing whether in trench or elsewhere in the Works.

"Pipeline" means those parts of the works comprising pipe, fittings, valves, valve chambers, other chambers, anchors, thrust blocks and all other appurtenances required for proper functioning, operation and maintenance of the pipeline.

27.3 APPLICABLE STANDARDS AND CODES

The following codes and standards, to the extent specified herein, form a part of this specification. The latest edition of these codes and standards shall govern the work.

ISO 4427	Polyethylene (PE) pipes for water supply - specifications
ISO 161-1	Thermoplastic pipes for conveyance of fluids - nominal outside diameter and nominal pressure- part 1: Metric series
ISO 1167-1 to 4	Thermoplastic pipes, fittings and assemblies for the conveyance of fluids
ISO 3126	Plastic pipe - Measurement of dimensions
ISO 4065	Thermoplastic pipes - Universal wall thickness table
ISO 6964	Polyolefin pipes and fittings - Determination of carbon black content by calcination and pyrolysis - Test method and basic specification.
ISO 9080	Thermoplastic pipes for the transport of fluids - Method of

	extrapolation of hydrostatic stress rupture data to determine the long-term hydrostatic strength of thermoplastic pipe materials.
ISO 11922-1	Thermoplastic pipes for the conveyance of fluids - Dimensions and tolerances Part: 1: Metric series.
ISO 12162	Thermoplastic materials for pipes and fittings for pressure applications - Classification and designation - overall service (design) coefficient.
ISO 13761	Plastic pipes and fittings - pressure reduction factors for polyethylene pipeline systems for use at temperatures above 200 C.
ISO 7005- 3	Metallic flanges - Part 3, Copper alloy and composite flanges
BS EN 12201	Plastic piping systems for water supply · polyethylene
ISO 974	Determination of the brittleness temperature by impact
ISO 2505	Thermoplastics pipes · Longitudinal reversion
ISO 6259	Determination of tensile properties
ISO 1133	Determination of the melt mass-flow rate (MFR) and the melt volume-flow
ISO 877	Methods of exposure to direct weathering

27.4 TECHNICAL REQUIREMENTS

27.4.1 Material

The Contractor shall identify the manufacturer of the resin, the resin type and classification. In addition, the Contractor shall provide evidence that the resin proposed is suitable for use at the design temperature and under the design pressures.

Any change in the material, the material specification, or the manufacturer's location shall be subject to prior approval of the Engineer.

Pipes and fittings shall be homogenous throughout and free from visible cracks, holes, foreign inclusions, blisters, dents or other damaging defects.

Material shall be uniform in opacity, density, interior smoothness, and other physical properties.

It shall have adequate resistance to weathering and other ageing from storage for a minimum of two years after manufacture.

The material of the polyethylene pipes and fittings which is in contact with or likely to come in contact with drinking water shall not constitute a toxic hazard, shall not support microbial growth and shall not give rise to unpleasant taste or odour, cloudiness or discoloration of the water.

The concentration of substances, chemical and biological agents leached from materials in contact with drinking water, and measurement of the

relevant organoleptic / physical parameters, shall not exceed the maximum values recommended by the World Health Organisation in its "Guidelines for Drinking Water Quality" or the EEC Council Directive on the "Quality of Water Intended for Human Consumption", whichever is more stringent in each case.

For the manufacturing of pipes & fittings new materials to be used only (Rework material is not acceptable.)

Pipe manufacturer shall confirm that all fittings to be provided for the pipe systems shall meet the same quality requirements as for the pipes to ensure the same performance for design life cycle.

The pipes and fittings shall be manufactured from polyethylene containing only those antioxidants, UV stabilizers and pigments necessary for the manufacturing process to fulfil the requirements of the specification.

All pipes and fittings shall be suitable for butt fusion or electro fusion techniques.

Contractor shall provide HDPE manufacturers guideline for the applicability of the material used. If required HDPE manufacturers shall provide assistance and training.

27.4.2 Physical Properties

Pipes and fittings shall be made of HDPE and shall comply with the requirements of ISO 4427 PE 100. The material shall be produced by a member of the PE 100 + Association.

The material used for the manufacturer of pipes and fittings shall be in accordance with Table-1 and Table-2 of clause 4.4 of ISO 4427-1. The minimum required strength (MRS) of the material compound shall be 10 MPa at 20°C. The design stress shall be 8 MPa.

Lifecycle durability of 80 years is to be confirmed.

Pressure reducing coefficients, as included in Annexure-A of ISO 4427-1, are also applicable. The thermal stability of polyethylene material shall meet the requirements of ISO 4427.

27.4.3 Pipe Dimensions

The pipe dimensions for water systems shall be based on standard dimensions according to ISO 4427 and measured in accordance with ISO 3126.

Straight pipe shall be supplied in standard lengths measured at $23 \pm 2^\circ\text{C}$, unless otherwise specified; coil lengths shall not exceed 100 m (328 ft).

Coiled pipes shall be coiled such that localized deformation is voided and diameter of the coil shall not be less than 18 dn.

27.4.4 Pipe Appearance

When viewed without magnification the internal and external surfaces of

pipes shall be smooth, clean and free from scoring, cavities and other surface defects. The pipe ends shall be cut cleanly and square to the axis of the pipe.

All polyethylene pipes to be used for the transmission and distribution of potable water shall be black and have blue stripes.

The carbon black content in the compound shall be $2.25\% \pm 0.25\%$ by mass when measured in accordance with ISO 6964. The dispersion of carbon black when determined in accordance with ISO 11420 shall be equal to or less than grade 3.

27.4.5 Fittings

The fittings shall be injection moulded and formed from material that is compatible to that of the pipe and shall be as resistant to the external and internal environments as the other demands of the pipe system.

At locations where HDPE pipe to metal connections is specified, Nylon-11 based polyamide coating system complying with the requirement of AWWA C224 or epoxy coated backing rings shall be used, or special restrained transition fittings subject to approval by the Engineer. The flanges shall be drilled to ISO 7005-2, as per the design requirements.

27.4.6 Fittings Appearance

When viewed without magnification the internal and external surfaces of pipes shall be smooth, clean and free from scoring, cavities and other surface defects. The fitting shall be blue or black.

27.4.7 Fittings Dimensions

The dimensions shall be measured in accordance with EN/ISO 3126.

27.4.8 Wall Thickness of Fittings

The wall thickness of the body of the fitting at any point shall be equal to or greater than the minimum wall thickness of the corresponding pipe.

27.4.9 Pipe Installation

- a. Trench excavation shall be carried out in accordance with Section Excavation of the specifications.
- b. Install pipe, fittings, and accessories in accordance with manufacturer's instructions:
 - Provide qualification details of the manufacturer's technical expert to be assigned to the Contract. The technical expert shall have expertise, experience and skills necessary for advising and monitoring all aspects of transport, storage, handling, installation and testing of pipes as appropriate.
 - The technical expert shall provide comprehensive technical assistance to the Contractor throughout Contract and

regularly monitor the Contractor's activities and report on shortcomings.

- c. The pipeline shall be within 1-inch of the specified line and the invert level shall be within 6mm of the specified value and shall be such that there is no back fall at any point on a gravity pipeline.
- d. Install bedding, surround and backfill in accordance with the pipe manufacturer's requirements.
- e. Install appurtenant facilities on the pipeline such as manholes, valve chambers as specified of the specification.
- f. Lay pipes from downstream to upstream unless agreed otherwise with the Engineer.
- g. HDPE pipelines can accommodate gradual changes of direction in the vertical and horizontal plane. However, the pipe should not normally be bent to a radius less than 25 times the outside diameter of the pipe.
- h. When cut pipe is required, ensure that the cutting is done by a machine, leaving a smooth cut at right angles to the axis of the pipe.
- i. Ensure that all pipes and fittings are sound and clean before laying. When pipe laying is not in progress, ensure that the pipe ends are at all times fitted with watertight plugs or caps. The plugs or caps shall only be removed for the purposes of making a connection of the pipe end or testing the pipeline. The plugs or cap shall be replaced immediately on completion of the test.

27.4.10 Backfilling

The selected fill material as shown on the Drawings shall be hand-compacted in layers not exceeding 150mm to complete the pipeline surround. Compaction shall be carried out equally on either side of the pipeline to prevent displacement. The backfill shall be hand-compacted up to 300 mm above the crown of the pipe. Any temporary support shall be gradually withdrawn during placing of the bedding and backfill materials to ensure that materials are placed against the trench side. The remaining portion of the trench shall be compacted in layers not exceeding 200 mm using approved mechanical rammers.

Where filter fabric is used to enclose granular pipe surrounds, the fabric will be placed on the prepared trench formation and carefully supported during pipe laying operations. When the pipe has been laid complete with granular surround to the correct level the filter fabric will be closed by forming a lap equal to trench width. Care shall be taken that the membrane is not punctured or damaged in any way during these operations and backfilling the trench.

Where concrete bedding or surround is specified, concreting shall be carried out as specified in Section - 35: PLAIN & REINFORCED CONCRETE. The backfill other than first 150 mm of cover shall not be placed before the compressive strength of the concrete has reached 15 MPa. The remaining portion of the trench shall be backfilled as specified.

27.4.11 Cutting Pipes

The Contractor shall be responsible for taking the measurements required to determine the lengths of cut portions of pipes for insertion as closing lengths in pipelines. The pipe and methods of jointing shall be such that the locations of fittings and lengths of pipe can be adjusted in the field to suit field conditions and variations in stationing. No extra payment will be made for such adjustments or for any welding, couplings, fittings, or special lengths required to meet this requirement.

The cutting of ductile iron and HDPE pressure pipes for inserting specials, fittings or closure pieces shall be performed by the Contractor. Cutting shall be carried out in a neat and workman like manner with an approved cutting machine without damage to the pipe and so as to leave a smooth end at right angles to the axis of the pipe. The cut ends of pipes shall be chamfered. The Contractor shall take every precaution to ensure that both the measurements and the cutting of pipes are to the accuracy required and should any errors occur the Contractor shall remedy same at his own expense and as the Engineer directs.

27.4.12 Butt Fusion Jointing

Butt fusion jointing shall only be used to join pipes of the same PE material with compatible MFR and with the same nominal wall thickness and outside diameter. The following procedures shall serve as a general guide only. The Contractor shall obtain detailed jointing instructions from the manufacturer who shall have a technical representative available at the Engineer's request during the jointing process.

- The butt fusion machine should be sited within a shelter and the ends of the pipe being joined should be covered or plugged to prevent through drafts.
- Each component that is to be fused should be held in position in the purpose-built clamping. The lengths of pipe hanging outside the jig should be supported by means of roller cradles.
- The pipe ends should be faced so that the finished surfaces are perfectly smooth free of visible ridges, valleys or other surface imperfections.
- The outside diameters of the pipe ends should match closely without the offset exceeding 10%.

- The pipe ends should be heated to the pipe manufacturer's recommended temperature and interfacial pressure. The Contractor should use a pyrometer or other surface temperature measuring device to confirm and record the actual surface temperature for each weld. Temperature indicating crayons should not come into contact with the surface to be welded.
- After the pipe ends have been properly melted, the heater tool should be removed within the specified time. The molten pipe ends should be brought together and allowed to cool without disturbance to form the permanent weld. The proper bead size and geometry specified for the pipe being welded should be formed.

27.4.13 Saddles/Sidewall Jointing

Saddle /sidewall fusion jointing shall be accomplished by using a mechanical saddle fusion machine that has been designed for this purpose to ensure proper alignment, temperature and force control. The following procedures shall serve as a general guide only. The Contractor shall obtain detailed jointing instructions from the manufacturer who shall have a technical representative available at the Engineer's request during the jointing process.

- Any dirt or coating that might interfere with the proper operation of the saddle fusion machine should be removed from the pipe and the surfaces of the pipe and saddle roughened to expose fresh material and any residue brushed away.
- Test fit the saddle fusion machine to ensure that alignment and contact are as they should be.
- Commence the fusion process and periodically verify the surface temperature using a pyrometer or other surface temperature measuring device. If temperature indicating crayons are used, they should not be used on a surface which comes into contact with the surfaces to be welded.
- After the heating period, remove the heater plate and check for the correct melt pattern on both the fitting and the pipe. Join the fitting to the pipe with the prescribed fusion force.
- Cool the joint without disturbance until the melt has formed a permanent weld. The joint should not be subjected to any external stresses until the fusion joint has cooled.

27.4.14 Electro Fusion Jointing

Electro fusion jointing involves heating the electro fusion joint internally, either by a wire coil at the interface of the joint or by a conductive polymer. Heat is created by an electric current passed to the conductive material in the fitting.

- Ensure that the fitting is dimensionally appropriate for welding to the Pipe. Clean the pipe surface in the joint area. Cut the end of the pipe square. Mark on the pipe surface the proper position of the fitting to be installed. Scrape the surface of pipe area to be joined, removing all surface degradation and contamination. Avoid contamination of the scraped pipe surfaces.
- Place the pipe and fitting in the clamping fixture to prevent movement of the pipe or fitting.
- Connect the electro fusion control box to the fitting and to the power source. Apply electric current to the fitting as specified in the manufacturer's instructions. Turn off the current when the proper time has elapsed to heat the joint properly.
- Allow the joint to cool for the recommended time and remove the clamping fixtures. Do not remove prematurely from the clamps as any strain on a joint that has not fully cooled can be detrimental to joint performance.

27.4.15 Mechanical Joints and Fittings

Many types of mechanical connection styles and methods exist. The Contractor shall submit suitable mechanical joints. All such joints shall be recommended and acceptance tested by the manufacturer of the pipe. Where marked on the Drawings end-load resistant fittings of an approved type shall be used.

When tightening polyethylene flanges care shall be taken to produce an equal torque load to the limits given by the manufacturer. A torque wrench shall be used. Since polyethylene creeps under load, it is essential that the bolts are re-tightened several times prior to commissioning to minimize the risk of leakage.

All joint materials and gaskets shall be suitable for use in the prevailing climate, soil, ground water, and potable water and irrigation water conditions.

27.5 TOOLS

The Contractor shall supply all necessary tools for cutting, chamfering, jointing, and testing and for any other requirement for satisfactorily installing the HDPE pipelines.

27.6 CONTROL OF WATER

The Contractor shall furnish, install and operate all necessary machinery, appliances, and equipment to keep the excavation sufficiently free from water during construction of the work to permit proper laying and jointing.

27.7 INSPECTION AND TESTING

27.7.1 Certification and Documentation

Contractor shall supply the Engineer with copies of certificate and test documents. Such documentation shall be subject to the Engineers' approval prior to shipping.

27.7.2 Test Results and Frequencies

The Manufacturer shall establish and maintain a current record of test results according to the requirements of the applicable standards and this specification. The Manufacturer shall perform all the tests required by ISO 4427 to demonstrate the characteristics and quality of the resin material and the dimensional tolerances of the pipe. The Manufacturer shall document all the tests, with frequencies and results as indicated in ISO 4427. The records shall be kept for 10 years as a minimum.

27.7.3 Inspection and Audit Requirements

Pipe shall comply fully with ISO 4427, the requirements of the PE 100 + Association and all the additional requirements of this specification.

To verify compliance with this specification, the Engineer shall reserve the right to appoint an independent third-party inspector to witness the applicable qualification tests, review production records, and inspect general handling and shipping procedures. The third-party inspector shall have full access to the testing and production facilities and will be a fully authorized representative of the Engineer.

27.7.4 Acceptance Criteria

The order shall meet the following criteria:

- a) A copy of the raw material Manufacturer's "Certificate of Quality Control Testing" covering each batch of raw material used for pipes purchased under this specification, shall be available for inspection by the Engineer on request.
- b) Pipe wall thickness shall be controlled by continuous scanning using ultra-sound or other qualified devices. These devices shall be regularly calibrated for accuracy by certificated agency.
- c) Successful test performance and acceptable results for the testing program outlined in this specification.
- d) Acceptable results, when tested by the Engineer from samples collected from storage of pipes at the site of works, for tests included in ISO 4427 and summarised in Table 27.1.

Table 27.1, Testing Requirements of HDPE Pipe

Sr. No.	Parameter to be Tested	Test Method
1	Mean Outside Diameter (Min. & Max.)	ISO 3126
2	Out-of-Roundness (Ovality)	ISO 3126
3	Wall Thickness (Min. & Max.)	ISO 3126
4	Minimum Required Strength	ISO 12162
5	Density	ISO 1183
6	Hydrostatic Strength at 20oC	ISO 1167
7	Elongation at Break	ISO 6259
8	Tensile Strength at Yield	ISO 6259
9	Longitudinal Reversion	ISO 2505
10	Carbon Black Content	ISO 6964
11	Melt Mass Flow Rate	ISO 1133

27.7.5 Defects

When the rejected item is a length or coil of pipe, the lengths or coils manufactured immediately before and after the defective lengths or coils shall be carefully examined. If further defects are found, this is sufficient cause for rejecting the entire batch. This will not apply to local damage that did not occur during manufacture, such as gouges or cuts during handling or transit.

27.7.6 Quality Assurance/Quality Control

A copy of the Manufacturer's QA/QC plan shall be submitted to the Engineer with its quotation for review and concurrence prior to award. If Manufacturer's facility is ISO certified, QA audit requirements shall be waived in favour of ISO 9000 registrar audits, unless the Engineer's trend analysis program indicates areas of concern.

27.8 PIPELINE TESTING

27.8.1 General

The Contractor shall submit for the Engineer's approval details of his proposed methods and programme for testing (including details of test equipment) and shall arrange for all tests to be witnessed by the Engineer. Unless otherwise directed by the Engineer, the Contractor shall ensure that no section of pipeline remains untested with pipe trenches and joints left exposed for more than 7 days after laying each pipeline section. The method of achieving this shall be entirely the Contractor's responsibility and no time extension or additional payments whatsoever shall be entertained on account of Contractor's failure to achieve this condition.

The Contractor shall provide all things necessary for carrying out testing and

cleaning including potable water, pumps, gauges, pipes, connections, stop-ends and all other temporary works.

Pipelines shall be properly completed and supported before being put under test except as hereinafter detailed.

The Contractor shall provide for transmitting the unsupported end thrusts to solid ground at the ends or into the sides of the trenches.

Before testing any pipeline, the Contractor shall ensure that the anchorage of bends is complete and thrusts from all branch outlets are properly stayed.

No testing will be permitted until seven days after thrust blocks and other holding down works have been completed.

Open ends shall be stopped with plugs, caps, or blank flanges properly jointed and restrained from movement.

No claims whatsoever will be entertained on account of leaking valves, or any other difficulties in closing of lengths of pipe work for testing, which shall be entirely at the Contractor's expense.

All water required for testing and cleaning the pipelines shall be potable water drawn off at locations approved by the Employer and shall be provided by the Contractor at his cost.

In addition to any tests of individual joints or other interim tests which may be specified elsewhere, the Contractor shall submit all parts of the pipelines to a final acceptance test. Notwithstanding the foregoing the Contractor may at any stage of construction, carry out such other tests as he considers desirable to check materials and workmanship on the pipeline but this shall not relieve the Contractor of his obligations to achieve successful tests under the Contract.

The Engineer shall have power to require the Contractor to vary any test procedure or pressure as he (the Engineer) thinks fit at no extra cost to the Employer.

The Contractor should note that neither the satisfactory testing of pipeline, section of a pipeline or any other pipe work, nor the acceptance of such testing by the Engineer or his representative shall in any way relieve the Contractor of any of his responsibilities and obligations under the Contract.

The Contractor shall notify the Engineer at least 24 hours before hand of his intention to test a section of pipeline having satisfied him in the first instance that the section of pipeline to be tested in the presence of the Engineer is satisfactory in all aspects.

Test gauges used for testing pressure pipelines shall be of conventional circular type of approved manufacturer, not less than 8-inch diameter, calibrated in bars or psi. Before any gauge is used, the Contractor shall

arrange for it to be calibrated independently and a dated certificate of its accuracy shall be provided to the Engineer.

One additional gauge as above shall be handed over to the Engineer for purposes of verification during testing.

Calibration of pressure gauges shall be carried out by the Contractor at regular intervals as required by the Engineer.

The Contractor shall remain responsible for the care of the works during testing of the pipe work.

27.8.2 Interim Pipeline Testing

The interim test shall be carried out after the pipeline section to be tested has been laid, jointed and backfilled to a depth of at least 12-inch above the crown of the pipe but leaving the joints exposed. The sections to be tested shall be approved by the Engineer. The joints between each tested section shall then be left exposed until the pipeline has passed the Final Test on Completion

For purposes of interim testing, the pipeline shall be divided into sections and each section shall be separately tested to the Engineer's satisfaction for deflection and pressure when each section is completed and before the joints are covered in the case of buried pipes.

The Contractor shall submit to the Engineer detailed procedures for performing hydrostatic pressure tests of installed piping, fittings, valves, meters and appurtenances for approval. Procedures for performing hydrostatic pressure tests for each section of pipeline shall indicate the location and capacity of the test pump, test pressure at the pump as well as that at the highest and lowest points procedures for venting the air from the pipeline and disposing the water after satisfactory testing.

Each pipeline or section thereof shall be filled with water and all air removed as far as possible. If permanent air vents are not located at all high points, the Contractor shall install suitable cocks at such points so that the air can be expelled as the line is filled with water. After all the air has been expelled all cocks shall be closed and the test pressure applied. The line shall be filled slowly to prevent possible water hammer. The test pump and gauge shall be connected to the pipeline at a location other than the highest point in the line to facilitate the release of air from the highest point.

The pressure in the pipeline shall then be raised steadily up to and maintained at rated pressure of the pipe (10-bars for PN10 HDPE pipe) for a period of not less than 12 hours to allow for absorption and achieve conditions as stable as possible for testing. The standing period will commence from the time at which the rated pressure (10-bars for PN10 HDPE pipe) was reached successfully, after which all exposed joints shall be carefully inspected for

evidence of leakage.

If neither appreciable movement of the pipeline nor any leakage has been observed during the visual inspection the section shall be subjected to the proper pressure test.

Pumping shall then be resumed and the pressure slowly raised to the specified test pressure i.e., 15-bars for PN10 HDPE pipe (1.5-times rated pressure of pipe). The test pressure shall be continuously maintained by the use of the pump for a period of at least 3 hours and the amount of makeup water required to maintain the pressure shall be accurately measured (to the nearest 1/8 litre) regularly every 30 minutes throughout the test.

The pipeline shall be deemed to have passed the test if:

- a) No water is visible coming out of the pipe or joints at any point
- b) Leakage is equal to or less than the number of imperial gallons per hour as determined by the following formula:

$$Q = \frac{n \times d \times \sqrt{p}}{1850}$$

where,

Q = Leakage in imperial gallons per hour

n = Number of joints in test section

d = Nominal diameter of pipe in inches

P = Average test pressure during the test in psi

During all testing, the trench generally and the joint pockets in particular shall be kept clear of water and should the trench become unstable due to work or leaking on testing or re-testing it shall be excavated to solid ground and made up with lean mix concrete or such other material as the Engineer may direct, all at the Contractor's expense. Should a test fail, the Contractor shall at his own expense replace defective pipes or fittings or make good leaking joints or otherwise rectify defective work. Cleaning, inspection and testing shall then be repeated until the work is to the Engineer's satisfaction and at no extra cost to the Employer.

The length of the section of pipeline to be tested shall not normally exceed 1,500 feet or as directed by the Engineer.

A simple stop end consists of a section of steel pipe about 1.5-3.0 feet long onto which a closing plate has been welded, containing the necessary opening for accommodating ingoing water and out-coming air. The stop end may also include an opening through which the test water may be pumped from the line, if necessary. The stop end may be jointed to the pipe to be tested by means of a standard coupling or other method approved by

the Engineer. Thrust blocks or temporary anchorages shall be provided to hold the stop end in place against the test pressure. The Contractor may also use propriety restrained joints in lieu of thrust blocks.

27.8.3 Final Acceptance Testing

The final acceptance test shall be carried out after all lengths have been joined together on completion of construction and interim tests have been carried out satisfactorily on the entire length of the pipeline.

Final pipeline acceptance procedures shall be as prescribed above for interim pipeline testing. The Contractor shall repair the pipeline if it fails to pass this test. The test shall be repeated and repairs affected until the pipe line passes the test.

27.8.4 Valves

Valves and all pipeline appurtenances shall be hydraulically tested together with the pipeline in which they are installed. Valves shall be tested for operation under working pressure and shall be adjusted so that they operate smoothly, seat properly and are installed to tolerances recommended by the manufacturer.

Before pressure testing is started the Contractor shall re-check pipes and valves for cleanliness and shall re-check the operation of all valves. The "open" ends of the pipeline (or sections thereof) shall normally be stopped off by blank flanges or cap ends additionally secured where necessary by temporary struts and wedges all anchor and thrust blocks shall have been completed and all pipe straps and other devices intended to prevent the movement of pipes shall have been securely fastened.

27.9 PIPELINE DISINFECTION

27.9.1 General

Pipelines shall be disinfected after they have been thoroughly cleaned and at the time the pipeline final acceptance testing is satisfactorily completed.

27.9.2 Disinfection of Pipelines

All potable water pipe, fittings, valves, meters and appurtenances shall be disinfected by the Contractor as specified herein.

All water and chlorine required for disinfection of pipelines shall be provided by the Contractor at his own expense. Bacteriological testing will be performed at a laboratory approved by the Employer the cost of which shall be borne by the Contractor.

The attention of the Contractor is directed to the requirements of these Specifications whereby he is responsible for preventing the entry of foreign material of any kind into the pipe work. The Contractor shall take extreme

care to keep the interior of the pipe work free of dirt and other foreign material. If in the opinion of the Engineer, direct or other foreign material enters the pipe work, which will not be removed by flushing, then the Contractor shall clean and swab the interior of the pipe work with a five percent hypochlorite disinfecting solution to the satisfaction of the Engineer.

After testing and immediately before commissioning, all pipelines shall be washed out and disinfected as follows:

- All mains shall be flushed out with clean water until there is no evidence of foreign matter or colour in the waste flushing water.
- A stock disinfecting solution shall be prepared by mixing for not less than 5 minutes, in a clean container, Sodium Hypochlorite solution (15 percent available chlorine) and distilled water in the proportion of 0.8 litres to 1000 litres of water by volume. After mixing, the solution shall stand for a further 5 minutes after which the clear supernatant liquid shall be decanted into another clean container. Stock solutions shall be made up fresh daily.
- The main to be disinfected shall be filled with potable water at the same time as the stock solution is added through a convenient air valve in such quantities (to be determined by the Contractor and approved by the Engineer) as will result in a final solution containing 50-70 mg/l free chlorine. Care shall be taken to ensure that the stock solution is added at a constant rate, commencing when water is fed into the main and ending as soon as the main is full.
- Every main charged with disinfection solution shall stand for 24 hours. A sample shall then be taken at a washout valve by the Contractor in the presence of the Engineer, from whom the sampling bottle shall be obtained. If the sample does not show at least 2 mg/l free chlorine, disinfection shall be repeated. If the sample is satisfactory the main shall be emptied, flushed out and filled with potable water and allowed to stand for 1 hour.
- Two further samples shall then be taken as before, one for a further determination of free chlorine and the other, in a sterilized bottle, for bacteriological analysis. If the free chlorine determination shows more than 4 mg/l free chlorine the main shall be flushed out again. If the bacteriological analysis is unsatisfactory, disinfection and sampling shall be repeated until satisfactory results are obtained before the main is commissioned.
- The Contractor shall provide all equipment, materials and testing apparatus, etc., as may be necessary for the effective disinfection of all pipelines.

27.9.3 Cleaning of Pipe work

All pipe work shall be cleaned by the Contractor after all pressure tests and disinfection operations have been performed and accepted by the Engineer. However, it is the responsibility of the Contractor to prevent all dirt and foreign mater from entering the pipe work and for cleaning each length of pipe and all fittings, valves, meters and appurtenances, of sand, dirt and foreign matter during the installation. Cleaning of chlorinated lines shall conform to the recommendations of the Chlorine Institute.

All potable water required for testing, flushing and disinfection of pipelines shall be provided by the Contractor at his own expense.

27.9.4 Disposal of Water Used for Testing, Disinfection and Cleaning

The Contractor shall provide suitable means for disposal of water used for testing, disinfection and flushing such that no damage results to facilities, structures or property. These means shall be subject to the approval of the Engineer and local authorities. Details shall be submitted to the Engineer upon request. The Contractor shall be responsible for any damage caused by his filling, testing, disinfection, flushing and wastewater disposal operations.

27.10 PACKING, MARKING AND VENDOR DOCUMENTATION

27.10.1 Pipe Identification and Packing

The marking information and sequence shall comply with ISO 4427. All pipes and fittings, including test samples shall be clearly and permanently marked using indent printing in a colour that contrasts with the pipe.

All pipes shall be indelibly marked at maximum intervals of 1m indicating at least the following information:

- The manufacturer's name and/or trademark;
- The dimensions (nominal outside diameter x nominal wall thickness);
- Material and designation;
- The nominal pressure (PN) in bar;
- The pipe series (S or SDR) (optional);
- The production period (date or code); and
- The number of this International Standard.

The word "water" shall also be included if the pipe is intended for potable water. The maximum quantity of pipe to have the same coil/length number is one silo (coiled pipe) or one bundle (straight lengths). The maximum combined length of pipe in the silo or bundle with the same coil/length number shall not exceed the maximum allowable coil length as specified,

When pipe material is boxed, me coil number shall be clearly marked on the

outside edge of the box or silo. Invoices and packing lists shall include the date of manufacture and coil/length numbers for all material in the shipment.

The fittings shall be packaged in bulk or individually protected where necessary in order to prevent deterioration and contamination. The package shall have at least one label with manufacturer name, type and dimension of the fittings and number of units.

27.10.2 Packaging and Transportation

The Contractor/Manufacturer shall provide packing and transportation procedures for approval by the Engineer and shall comply with the following requirements.

A) Delivery

Delivery of the plastic pipes and fittings to site, shall be no later than six months after the stamped manufacture date.

B) Weathering

A certificate from the pipe/fitting manufacturers shall be provided, confirming that the products may be stored in the open for minimum of 2 years without any adverse effect.

C) Tie-downs

Tie-downs shall be at least 100 mm (4.0 inch) wide and be clean and free from sand, gravel and other such materials. For straight length pipe (up to 12 m (39 ft), a minimum of 6 tie-downs are required.

D) Pallets

The pallets shall be suitable for transporting the material from the place of manufacture to the designated receiving location without causing any damage to the pipe. The pallets shall not contain any broken planks or extremities that may damage the coiled pipe or straight lengths. They shall be durable enough to prevent loose pallet nails from gouging the bottom coil/straight length.

E) Overhang

Pipe shall not overhang at either end of the trailer.

F) Stacking

The Contractor/Manufacturer shall not ship small coils stacked inside silos of larger coils. Frames manufactured for the containment of straight lengths of polyethylene pipe during transport and storage shall not contain nails or other fastening devices that may damage the pipe.

G) Trucking

Where pipes are transported by vehicles, the vehicles should have a flat bed

and be free from sharp edges or projections. During transport, polyethylene pipes shall be protected from diesel fumes and be continuously supported to prevent movement between the material and its support.

H) Silos

Silo packs of coiled pipes shall be squarely stacked and well supported on pallets. Coils shall not overhang the pallets and, shall not be stacked higher than 2.3 m (8.0 ft)

27.11 STORAGE OF PIPES AND APPURTENANCES

All pipes and materials shall be stored in accordance with the manufacturer's recommendations and the following:

- Jointing materials and operational gear shall be stored under cover. Pipes may be stored in the open, but shall be placed on adequate timber bearers to prevent damage to sheathing or sockets. Pipes not delivered on manufacturers' pallets may be stacked one above the other up to three pipes high provided suitable protective packing is placed between them. If any pipes or fittings show signs of corrosion or deterioration during storage either they shall immediately be treated at no extra charge by the Contractor to arrest and prevent the corrosion or removed from site as the Engineer directs.
- The Contractor shall properly stack the pipes in his storage area and the stacks shall be laid out in a regular pattern and the limits of each stack marked so that the movement of cranes and vehicles is restricted to access tracks between stacks and the control of delivery and removal of pipes is facilitated.
- The number of tiers of HDPE pressure pipe stacks shall be as per the Manufacturer's instructions and approval of the Engineer. Each pipe, including those in the bottom course, shall bear evenly upon not less than three timbers with an aggregate width not less than 300mm. The pipes shall be stacked parallel to each other.
- The timbers supporting each course of pipes in a stack shall be of uniform thickness and stiff enough for the pipes to be rolled across the stack and shall be supplied by the Contractor at his own expense.
- The outermost pipes in each course shall be secured against rolling by sandbags or by wedges.
- Where the pipes are to be delivered and stacked by the Contractor on sites along the pipeline route, the areas where the pipes are to be stacked shall, if required, be graded flat by the Contractor at his own expense to provide a firm and even surface and shall be kept free from loose stones, rubble or waste liable to damage the pipes.

- Jointing materials, valves, fittings and specials, meters, gauges and polyethylene sheeting shall be stored in covered storage areas until required for installation.
- Pipe shall be removed from storage and directly distributed to their point of installation only in such quantities as can be installed in one week.

27.12 MEASUREMENT AND PAYMENT

27.12.1 Measurement

Measurement for HDPE pipes for water supply shall be made for the actual quantity of the work done in linear metre or linear feet (whichever is included in Bill of Quantities) on the axis of the piping including all fittings, bends, crosses, tees etc. No deduction will be made for the laying lengths of valves, fire hydrants, specials, etc. installed in the lines

27.12.2 Payment

The unit rate quoted in the Bill of Quantities for supplying and laying HDPE pipe for water supply shall be the full compensation for all cost of completing the item of work as per provision of this section and shall include cost of pipe, its carriage to the site, laying, cutting, joining, testing and disinfecting, etc. and all incidentals to complete the item except valves assembly and backing blocks, which shall be paid separately.

SECTION - 28: PIPELINE APPURTENANCES

28.1 SCOPE OF WORK

The work included in this section consists of providing, laying, jointing, cleaning, disinfection, testing and commissioning of pipelines appurtenances for water supply. The Contractor shall provide all labour, materials and equipment necessary including removing from storage, transporting to sites, excavation, backfilling and compaction, laying, jointing and testing, disposal of excess excavated materials and removal of surplus pipes, fittings, valves and jointing materials. The responsibility for the safety and soundness of all material shall rest with the Contractor.

The Contractor is advised to carry out any tests at his cost needed to satisfy himself regarding the soundness of the valves, appurtenances and jointing materials including the pipeline installation before acceptance for testing by the Engineer.

28.2 GATE VALVE

Gate valves shall be of cast iron body conforming to BS 5150 with bolted bonnet, solid wedge, inside screw, non-rising stem, flange connection and fitted with cast iron hand wheel.

Specific clauses of BS 5150 are amplified as follows:

Sr. No.	Parameter	Details
1	Clause 3: Types of Valves	Solid wedge with non-rising stem
2	Clause 4: Nominal Sizes	All valves shall be of flanged end with sizes as specified on the Drawings
3	Clause 5: Nominal Pressure	PN 16 unless otherwise specified on the Drawings
4	Clause 9: Body Tapping	As specified to BS 21 (1S0 /R7) fitted with bronze or gunmetal plug
5	Clause 14: Operation	Gate valves shall be provided with cast iron hand wheels or square heads for tee key operation as required. The direction of operation shall be clockwise to close the valve. Hand wheels shall require a force not greater than 20 kg on the outer rim to operate with a balanced pressure across the valve. Tee keys shall require a force not greater than 12 kg applied at the opposite ends of a standard key from

Sr. No.	Parameter	Details
		the closed position.
6	Clause 19: Test Certificates	The Contractor shall provide a test certificate confirming that the valves have been tested in accordance with BS 5150 and stating the actual pressure and medium used in the test. In addition, the Contractor shall ensure that the Engineer has access to the manufacturer's works at all reasonable times for the purposes of inspecting the assembled valves and witnessing testing.

The material of construction of gate valves shall be as under:

Sr. No.	Part	Material
1	Body	Grey cast iron
2	Bonnet	Grey cast iron
3	Wedge	Grey cast iron
4	Gland	Grey cast iron
5	Stem	Stainless steel 304
6	Seat Ring, Wedge Ring	Stainless steel 304
7	Back Seat Bush	Stainless steel 304
8	Nuts & Bolts	Stainless steel 304
9	Painting	Wet blue epoxy paint, corrosion resistant

28.3 CHECK VALVE

Check valve shall comply with the requirements of BSS 5153. The valve shall be of swing type with quick acting single door and pressure rating of PN 16 unless otherwise specified on the Drawings. The valve design shall ensure closure in the shortest possible time following deceleration of the water column, ideally reaching its seat without slamming at the instant forward motion of the column cases.

The material of construction of check valves shall be as under:

Sr. No.	Part	Material
1	Body	Grey cast iron
2	Bonnet (Top Plate)	Grey cast iron
3	Disc	Grey cast iron
4	Seat Rings	Stainless steel 304
5	Hinge Pin	Stainless steel 304

Sr. No.	Part	Material
6	Disc Hanger	Grey cast iron
7	Gasket	Flexible graphite
8	Nuts & Bolts	Stainless steel 304
9	Painting	Wet blue epoxy paint, corrosion resistant

Swing Check Closure is affected by gravity (Weight of disc) and reverse flow. The pivot point of the swing check is outside the periphery of the disc and the greater the head, the greater the possibility that the fluid will flow back through the valve before the disc can be shut off. To effect complete shut off, the disc of a swing check valve must travel through a 700 to 900 arc to the valve seat. Without resistance to slow the disc's downward thrust and reverse flow, the shut off can result in slamming and damaging water hammer.

28.4 AIR-RELEASE VALVE

Automatic air relief valve shall be designed to meet the following conditions:

- Discharge air during charging of the pipeline.
- Admit air during emptying of the pipeline or when the pipe in pressure falls below atmospheric pressure during a surge event.
- Discharge air accumulated at local peaks along operating conditions the pipeline under normal

Conditions 'a' and 'b' shall be met by the employment of a large orifice capable of handling large volumes of air at a high flow rate and condition 'c' by a small orifice capable of discharging small quantities of air as it accumulates. Valves with air intakes or exhaust facilities shall have approved screening arrangements to prevent the ingress of air borne sand.

The valve shall conform to AWWA C512 pressure rating of PN 16 unless otherwise specified on the Drawings. Valve Body ends shall be flanged with raised faces and drilled to EN 1092-1.

The material of construction of air release valves shall be as under:

Sr. No.	Part	Material
1	Body	Grey cast iron
2	Bonnet (Top Plate)	Grey cast iron
3	Float Ball	Stainless steel 304
4	Gasket	EPDM - Asbestos Free
5	Nuts & Bolts	Stainless steel 304
6	Painting	Wet blue epoxy paint, corrosion resistant

Each valve shall be provided with isolating valves as detailed in the Drawings.

28.5 FIRE HYDRANT

The fire hydrant can be any of following two types as specified on the Drawings:

a. Screw Down Type

The metal of the fire hydrant shall conform to B.S. 750 and suitable for a maximum working pressure of 16 bars. The body shall be best quality, closed grain grey cast iron with spindle of magnese bronze having tensile strength of not less than 11.0 tons per square in machined from solid rolled bars, the seating valves and other parts shall be of best quality gun metal with Brinell Hardness No. 80. The direction of closing shall be by clockwise rotation and outlet shall have screwed joint for accommodating 2-1/2" (65 mm) diameter hose connection. Inlet flanges of hydrant shall be suitable for jointing with flanges of hydrant bends. All fire hydrants shall be coated with three coats of solution from an approved manufacturer to give a uniform protective coating on cast iron.

b. Wet Barrel Type

The scope of work shall cover the supply, design, manufacture, testing in the factory, packing, insurance, delivery to site, unloading, installation, testing and commissioning of Fire Hydrants pipes and fittings with all the necessary accessories in accordance with Drawings and these technical specification

Wet stand pipe fire hydrants shall be of two-way Pedestal type and shall have two 2½" nominal size hose outlets and a pumper outlet in addition to the hose outlets, otherwise specified. The hydrant shall have a minimum rated working pressure of 175 psi otherwise specified.

The material of construction of wet barrel type fire hydrant shall be as under:

Sr. No.	Part	Material
1	Hydrant Body	Grey cast iron, 6-inch diameter
2	Pumper/Hose Nozzle	Bronze
3	Pumper/Hose Nozzle Cap	Grey cast iron
4	Gasket	EPDM - Asbestos Free
5	Nuts & Bolts	Stainless steel 304
6	Painting	Wet red epoxy paint, corrosion resistant

Fire Hydrants shall be UL listed and FM approved.

28.6 VALVE CHAMBERS

Chambers for gate valves, air valves, washouts, etc. shall be constructed in accordance with the details shown on the Drawings, or as directed by the Engineer.

Brick masonry, Portland cement concrete, and other materials shall meet the specified requirements of the relevant sections of these specifications.

28.7 VALVE BOX

Valve boxes shall be provided for all valves which are installed below ground level in conformance with the details shown in the Drawings. Valve boxes shall be of the heavy-duty type capable of withstanding a ten-ton load when located within carriageways. Ordinary valve boxes shall be used in other locations. All valve boxes shall be of the lockable type. They shall be installed on concrete bases as shown in the Drawings.

28.8 THRUST BLOCKS

The Contractor shall construct all thrust blocks as shown on the Drawings. Thrust blocks shall be constructed to the dimensions shown on the Drawings. The thrust blocks are designed for soil parameters as shown on the Drawings. Where considerably better ground conditions, such as rock, are encountered, the dimensions of the particular thrust blocks may be reduced. Supporting calculations for any reduced size thrust blocks must be submitted to the Engineer at least 48 hours before construction of that particular thrust block commences.

Unless otherwise specified or directed, thrust blocks shall be provided on pipelines laid to gradients steeper than 1:20; up to 1:15 every third pipe shall be anchored, up to 1:10 every second pipe and at 1:5 every pipe should be anchored.

Concrete shall extend to undisturbed ground on thrust faces or thrust blocks and on both faces of anchor blocks.

Each thrust block shall be designed to have a sufficient bearing area and shall be placed to safely transmit to the surrounding point. Thrust devices shall be cast-in-place concrete. Thrust blocks shall be constructed of Class-C concrete as included in SECTION-35.5.2 and shall be placed between fitting and trench wall or trench bottom, as the case may be. The bearing faces of the block shall be placed against freshly cut and undisturbed trench wall or bottom of sound material. If the thrust exceeds the bearing value of the surrounding soil, the soil shall be pre-compacted before placing concrete. All concrete shall be kept behind the sockets and flanges of fittings. Formwork shall be constructed wherever necessary to confine the concrete to the prescribed dimensions for the block. All form lumber shall be removed before

testing.

The blocks shall, unless otherwise shown or directed by the Engineer, be so placed that the pipe and fittings joints will be accessible for repair. Before internal pressure is applied to a pipeline, all concrete thrust blocks shall have been constructed and cured for a minimum of 7 days.

28.9 APPROVAL OF MATERIALS AND EQUIPMENT

As soon as practicable but within thirty-days after the receipt of notice to proceed and before any material or equipment is purchased, the Contractor shall submit for approval by the Engineer a complete schedule of materials and equipment to be incorporated in the work, together with the names and addresses of the manufacturers and their catalogue, item numbers and trade names. The schedule shall include catalogue cuts, diagrams, drawings, and such other descriptive data and as may be required by the Engineer. Samples of materials shall be provided as required. No consideration will be given to partial lists submitted from time to time. Approval of materials and equipment under this provision shall not be construed as authorization of any deviations from the specifications unless the attention of the Engineer has been directed to the specific deviations. Laboratory results and certifications, specified or otherwise required, shall be submitted prior to delivery of the material or equipment to the site.

28.10 TESTS AND ACCEPTANCE

All valves, fittings and accessories delivered to the job site shall be accompanied by test reports certifying that the valves, couplings and/or fittings and accessories conform to the relevant specifications.

The Contractor shall take the necessary measures to allow the Engineer to be present during the tests at the factory, if the Engineer finds it necessary to do so. Failure to present the aforementioned certificate, or to inform of the date and time of the factory tests, shall constitute grounds for rejection of the valves, fittings or couplings that do not comply with these conditions.

Acceptance of such material shall only be possible if the rejected batch of valves, fittings and joints is tested under the Engineer's supervision, at the Contractor's expense, and only those passing the tests shall be accepted.

In addition, the right shall be reserved for the Engineer to subject any consignment of valves, fittings and couplings to any or all of the tests, over and above the tests conducted by the manufacturer. The Contractor shall furnish all labour, material and equipment necessary to assist in performing the tests and inspecting the valves, fittings and couplings.

28.11 MEASUREMENT AND PAYMENT

28.11.1 Measurement

Measurement for fire hydrants, valves air release valves, washout valves etc. shall be made in number and shall include the chamber and all other materials to complete the work as per Drawings including connection with pipeline. Backing blocks for bends, tees etc. shall be measured in cubic foot or cubic metre (whichever is included in Bill of Quantities).

28.11.2 Payment

The unit rates quoted in the Bill of Quantities for the supply and installation of fire hydrants, air release valves, sluice/gate valves, washout valves including chambers and other specials and shall be full compensation for supply, installation, testing, commissioning, disinfecting and all incidentals to complete the items of the work as per Drawings. The thrust blocks provided will be measured separately for payment.

SECTION - 29: PIPE BEDDING

29.1 SCOPE OF WORK

Wherever specifically called for by means of notes on the contract Drawings or by written order of the Engineer, the Contractor shall furnish and place sand bedding under water lines, drain pipes and other structures as a separate item of payment.

29.2 PURITY AND STACKING

Sand bedding shall be from a source and of specifications approved by the Engineer.

The sand stone shall be free from clay, salt, alkali, organic matter, shale, loam, soft flaky particles and other deleterious substances. It shall be stacked at the place designated by the Engineer and kept free from the admixture of deleterious materials mentioned herein. The sand shall not contain clay/silt more than 5%. Laboratory testing prior to its use under bedding will be arranged.

29.3 PLACING OF BEDDING MATERIAL

The material for bedding shall be placed to the specified thickness and compacted by rammers of approved weight. The compaction level shall not be less than 95% of modified dry density as determined by AASHTO T-180.

29.4 MEASUREMENT AND PAYMENT

29.4.1 Measurement

The measurement shall be made by volume for the actual quantity of the work done and the unit of measurement shall be cubic foot or cubic metre (whichever is included in Bill of Quantities).

29.4.2 Payment

Payment for this item of work shall be made for the actual quantity of work done as specified in this section, at the unit rate quoted in the Bill of Quantities.

SECTION - 30: WATER SUPPLY SERVICE CONNECTIONS

30.1 SCOPE OF WORK

Work under this section consists of furnishing all material, plant, machinery, labour and performing all functions and operations in connection with the execution of service connections for water supply, in strict accordance with the Drawings and applicable specifications and as directed by the Engineer.

30.2 MATERIAL REQUIREMENTS

The earth work shall be performed as per requirements of Section - 26: EARTH WORK FOR WATER LINES.

Service connection pipe shall be of HDPE of diameter as shown on the Drawings. Whereas, Clamp Saddle shall of Polypropylene with built-in rubber washer. Fittings and specials shall be as recommended by the manufacturer of the pipe and as approved by the Engineer. The plugging of the end will be part of the item.

30.3 CONSTRUCTION REQUIREMENTS

Service connection shall be executed as per Drawings or as indicated by the Engineer.

Connection arrangement shall be as per requirements/recommendations of the manufacturer of the pipe and as directed by the Engineer. Service pipe shall be connected with the pipe running either in front of the individual plot or from other side of the road. Service end of the pipe shall be duly plugged.

30.4 MEASUREMENT AND PAYMENT

30.4.1 Measurement

Measurement for service connection shall be number of service connections installed, tested and commissioned including all fittings, saddle arrangement, etc. but excluding cost of pipe as per specifications and accepted by the Engineer for payment.

Measurement for HDPE pipe of specified diameter is in linear metre or linear feet (whichever is included in Bill of Quantities) on the axis of the pipe.

30.4.2 Payment

Measurement as carried above shall be paid for at the unit rate quoted in the Bill of Quantities and shall be full compensation for furnishing all materials, tools, plants, labour and incidentals to complete the work.

PART - 7: SEWERAGE SYSTEM

SECTION - 31: EARTH WORK FOR SEWERS

31.1 SCOPE OF WORK

The work shall consist of furnishing all materials, equipment and labour for excavation, trenching and backfilling for sewers, drainage facilities, structures and all other appurtenances of sewage collection system, in accordance with Drawings to proper line and grade and refilling the trenches and dressing them to proper surface.

31.2 CLEANING AND GRUBBING

The sites of all excavations shall be cleared of all shrubs, plants, bushes, large roots, rubbish and other surface materials. All such materials shall be removed and disposed of in a manner, satisfactory to the Engineer. All trees and shrubbery, that are designated by the Engineer, or his representative shall be adequately protected and preserved in an approved manner.

31.3 EXCAVATION

31.3.1 General

The Contractor shall do all excavation of whatever substance encountered to the depth shown on the Drawings or as otherwise specified. Excavation shall include without classification the removal and disposal of all materials of whatever nature that would interfere with the proper construction and completion of the work and shall include the furnishing, placing and maintenance of supports for the sides of the excavations. The work shall also include all pumping, ditching, dewatering and other measures required for the removal and exclusion of water. During excavation, material suitable for backfilling shall be stock-piled in an orderly manner at a sufficient distance from the bank of the excavation to avoid over-loading and to prevent sides from caving. Top soil should be stock-piled separately for subsequent reuse as necessary. All excavated material unsuitable or not required for backfilling shall be removed and disposed of at a location approved by the Engineer.

For contract purposes hereunder, the earth excavation work has been classified into two categories, earth excavation in trenches, and earth excavation for structures.

31.3.2 Earth Excavation in Trenches

Except as otherwise provided herein, excavation for a sewer line shall be open cut trenches with vertical side and not more than 200 feet of any trench in advance of the end of the built sewer shall be opened at any time and unless written permission to the Contractor is given by the Engineer. The trench shall be excavated to its full depth for a distance permitted for the

sewer to be laid. Trenches for sewer-lines and appurtenances shall be to the lines and grades shown on the drawing or as ordered in writing by the Engineer as necessary for the proper completion of the work. Bell holes and depressions for joints shall be dug after the trench bottom has been graded. The pipe except for joints shall rest on the prepared bottom for its full length. Bell holes and depressions shall be only of such length, depth and width as required for properly making the particular type of joint. Stones shall be removed to avoid point bearing.

Where the bottom of the excavation is in material which, in the judgment of the Engineer by reason of its hardness cannot be excavated to provide a uniform bearing for the pipe, said material shall be removed to minimum of 6" below the grade of the bottom of the pipe, and the trench backfilled to the required pipe sub grade with sand or other material acceptable to the required depth or with concrete Class-E, if so ordered. In no case material removed from such excavations shall be used as backfill material unless approved by the Engineer. All instructions shall be in writing by the Engineer.

31.3.3 Earth Excavation for Structures

All earth excavation under this Contract, which is not included under the classification of "Earth Excavation in Trenches " shall be classified and paid for as earth excavation for structures.

The Contractor shall provide adequate timbering or shoring for excavations. Should the sides and ends of any excavations give way the contractor shall, at no extra cost, remove all disturbed ground. Any excavation carried outside the limits shown on Drawings and specified herein as the payment limits, shall not be treated as excavation and shall not be paid for.

When foundation level is reached, the Engineer's Representative will inspect the exposed ground and give directions as to what further excavation, if any, he considers necessary. The excavation should be done in such a manner, as to ensure that the work rests on a solid and perfectly clean foundation. If the Contractor allows any portion of such foundations to deteriorate due to exposure, he shall make good the foundation to the satisfaction of the Engineer without extra cost.

31.4 ALIGNMENT AND GRADE

The sewers are to be laid to the alignment and gradient shown on the Drawings, but subject to such modifications as shall be ordered by the Engineer from time to time to meet the requirements of the work. No deviations from the lines, depths of cutting or gradients of the sewers shown on the Drawings and sections shall be permitted except by express directions in writing of the Engineer.

31.5 SETTING OUT SIGHT RAILS

The sewer shall be constructed and laid to a true grade and in straight lines between curves as shown on the plan. The sewer shall be laid and constructed to their proper levels with the aid of suitable boning rods and sight rails which shall be fixed according to the requirements of the Engineer at intervals not exceeding 40 feet, and also by levelling along the invert with levelling instrument. The sight rails and boning rods shall be provided, fixed and maintained by the Contractor who shall also provide and maintain suitable levelling instruments and equipment and shall set the positions and levels of the sewers and other work according to the Drawings and any instructions which he may receive from the Engineer. All sight rails and posts shall be well seasoned deodar timber of ample size and strength. The rails and boning rods shall be suitably and accurately planned and no warped or otherwise defective or damaged sight rails or boning rods shall be used. Sight rails shall be secured to the posts by strong steel clamps to the approval of the Engineer and in such a manner that they shall be fixed as immovable, in relation to the correct lines and levels. All boning rods and sight rails shall have the centre line accurately marked thereon, by a fine saw cut and shall be painted black and white to the requirements of the Engineer. All boning rods shall suitably be shodded with iron. At least four separate sight rails shall always be maintained in correct level and alignment along the line of sewer at every place where construction work is proceeding and the alignment and level of the sight rails shall be checked by the level and line at least twice every day to ensure that no disturbance or interference of the alignment and level have taken place. Whenever required the Contractor shall erect and maintain such additional sight rails as the Engineer shall direct. The Contractor shall, at all times, see that his workmen or other unauthorized persons are not allowed, accidentally or otherwise, to tamper or interfere with sight rails or other alignment or level marks.

All bends and curves shall be set out mathematically in a manner to be approved by the Engineer and the Contractor shall provide and maintain for the purpose such additional sight rail posts and other wrought and rough timber work, steel wire and other articles as the Engineer shall require from time to time.

31.6 SHEETING AND BRACING

If ordinary open-cut excavation is not possible or advisable, sheeting and bracing shall be furnished and installed in excavations to prevent damage and delay to the work and to provide working conditions, which are safe. The Contractor shall furnish and place all shoring, sheeting, wall braces, timbers and similar items necessary for the safety of work, the general public and adjacent property. Sheeting, shoring and wall bracing shall be removed as the work progresses and, in such manner, as to prevent damage to the finished work and adjacent structures and property. As soon as it is withdrawn

all voids left by the sheeting and bracing shall be carefully filled with selected material and compacted. The Contractor shall be fully responsible for the safety of the work in progress, for the finished work, the workmen, the public expenses, as part of the work under the excavation items and at no extra cost.

31.7 DEWATERING OF TRENCHES

As part of the work under the excavation items and at no extra cost, the Contractor shall build all drains and do ditching, pumping, well-pointing, bailing and all other work necessary to keep the excavation clear of ground water, sewage and storm water during the progress of the work and until the finished work is safe from injury, the Contractor shall provide all necessary pumping equipment for the dewatering work, as well as operating personnel, maintenance, power etc. all at no extra cost. All water pumped or drained from the work shall be disposed of in a manner satisfactory to the Engineer. Necessary precautions against water flooding shall be taken.

31.8 MAINTENANCE OF EXCAVATIONS

All excavation made hereunder shall be properly maintained while these are open and exposed. The Contractor shall provide warning lights, signs and similar items sufficient suitable barricades. The Contractor shall be responsible for any personal injury or property damage due to his negligence.

31.9 PROTECTION OF EXISTING FACILITIES

The Contractor shall take special care of existing sub-surface facilities likely to be encountered during the excavation for their protection, such as sewers, drain pipes, water mains electric cables, communication cables and the foundations of adjacent structures. The Contractor shall be responsible for any damage to any such facility and shall repair the same at his expense whether or not the facility has been shown on the drawing.

31.10 DISPOSAL OF SURPLUS EXCAVATED MATERIAL

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

31.11 BACKFILLING

31.11.1 General

After the completion of sewer line, drainage facilities foundations, walls and other structures below the elevation of the final grade all voids shall be backfilled with suitable materials specified below.

31.11.2 Backfilling for Structures

Backfilling operations for structures shall be performed as part of the Contractor's work under the payment items for earth excavation and at no extra cost. Backfill material for foundations, walls and other structures shall consist of excavated soil, which is free from stones and hard clods not larger than 3 inch in any dimension, and also free from trash, lumber and other debris. Backfill material shall have enough moisture for proper compaction and shall be compacted in an approved manner to 90 percent of maximum density for cohesive soils and 95 percent of maximum density for cohesion less soils. Backfill shall not be placed against foundation walls earlier than 4 days after placing of concrete or brick masonry.

31.11.3 Backfilling for Trenches

After the sewers have been constructed and tested as specified and to the satisfaction of the Engineer, the trench shall be backfilled. Utmost care shall be taken in doing this so that no damage shall be caused to the sewer and other underground utilities. After this has been laid the trench and other excavation shall be backfilled carefully in 150mm layers with earth as approved by the Engineer, each layer being watered to assist in the compaction unless the Engineer shall otherwise direct.

31.12 MAXIMUM DENSITY DETERMINATION FOR COMPACTED SOIL

The maximum density of the soil shall be determined in accordance with the latest revision of “American Society for Testing Materials (ASTM) Standard D 1557 Density Relations of Soils, using 6.8 kg Rammer and 450mm Drop”.

31.13 TESTING DENSITY OF SOIL

The Engineer will make tests using the calibrated sand cone method/core cutter method to determine the density of soil in place in accordance with ASTM Designation D 2558, latest revision. If soil in place fails to meet the specified degree of compaction the areas represented by the failing tests shall be re-excavated and compacted to the specified density in the manner directed by the Engineer at no extra cost.

31.14 TOP SOIL

Top soil, which has been stock-piled during excavation, shall be used for the top 150mm of backfill, in locations as ordered by the Engineer. Top soil shall be saturated with water and after it has dried, shall be spread to the required final grade and of required density. The work shall be performed at no extra cost.

31.15 PROXIMITY TO BUILDINGS

Where buildings in the opinion of the Engineer near excavation are likely to be affected, the Contractor shall provide shoring to protect such buildings in

addition to timbering of trenches. The Contractor shall be required to leave timbering inside trenches if so required by the Engineer for protection of these buildings at no extra cost.

31.16 LENGTH OF TRENCHES IN ADVANCE OF CONSTRUCTION

Unless otherwise directed in writing by the Engineer of the work not more than 200 ft in advance of constructed or laid sewer shall be left open at any time.

31.17 DISPOSAL OF FILTH AND GARBAGE

No night-soil, filth and garbage met with during the excavation shall be allowed to be deposited on side of road/street so as to cause nuisance or obstruction to traffic. The same shall be disposed of by the Contractor to a place to the satisfaction of the Engineer.

31.18 DISPOSAL OF SURPLUS EARTH

The Contractor shall dispose of all surplus excavated materials not required to be used on the work. This shall include surplus earth after refilling and compaction.

31.19 MEASUREMENT AND PAYMENT

31.19.1 Measurement

The measurement shall be made for the actual quantity of the work done in cubic foot or cubic metre (whichever is included in Bill of Quantities). The maximum width of the trenches allowed for payment for various pipe sizes are included in the Drawings.

31.19.2 Payment

The unit rate tendered in the Bill of Quantities for excavation of trenches for sewer lines shall be considered as full compensation for the work specified in this section and shall include all excavation, backfilling, compacting, constructing and removing all temporary arrangements, pumping and dewatering disposal of surplus materials, removal of soft soil from bottom of trenches, removing the surface material and all incidentals to complete this work in all respects.

SECTION - 32: REINFORCED CEMENT CONCRETE PIPE SEWERS

32.1 SCOPE OF WORK

The work shall consist of furnishing all pipes, plant, labour, equipment, appliances and materials and in performing all operations required for installing and testing the sewer pipes of reinforced cement concrete in strict accordance with the specifications of this section and the applicable drawing and subject to the terms and conditions of the contract.

32.2 REINFORCED CEMENT CONCRETE PIPES

32.2.1 General

All reinforced concrete pipes furnished and installed under this contract shall conform to ASTM C76 “Reinforced Concrete Culvert, Storm Drain and Sewer Pipe” and as per provisions of these technical specifications, using structural steel reinforcement. Sulphate Resistance Cement shall be used for sewers.

32.2.2 Classes of Pipe

The reinforced cement concrete pipes to be furnished and installed under this contract shall be of the strength classes shown on the Drawings and designated in Bill of Quantities of the Bidding Documents.

The strength classes shall be identified as one or more of the following:

- Class-I
- Class-II
- Class-III
- Class-IV
- Class-V

The design requirements for these five classes of reinforced cement concrete pipe shall be as described in ASTM C76-2003, or its latest version, Tables I through V for the respective strength classes. Unless otherwise called for in other parts of these Bidding Documents or applicable variation order, all reinforced cement concrete pipes under this contract shall comply with the Wall B design requirements as set forth in said Tables I through V of ASTM Designation ASTM C76-2003, or its latest version.

32.2.3 Basis of Acceptance

RCC pipes shall be used conforming to ASTM C76-2003, or its latest version, Class III, Wall "B" and acceptance of same shall be determined on the basis of following test results:

A) Concrete Compressive strength

- Compressive strength of concrete used for the fabrication of the RCC pipe shall be minimum 4000 psi;
- Compression test determining concrete compression strength may be made on concrete cylinder compacted and cured as pipe; and
- All type pertaining information for conducting the compressive test is given in the specification ASTM C76-2003, or its latest version, which should be followed.

B) Inspection

- Whether the required quantity of steel reinforcement is provided and placed for the fabrication of RCC pipe as required by the Specification; and
- Manufactured pipe for visual defects and imperfection such as diameter, wall thickness, length of pipe and smoothness of the inner/outer surface of the pipe.

C) Three Edge Bearing Test

- The three-edge bearing test shall be conducted as required by ASTM C76-2003, or its latest version; and
- Test load expressed in pounds-force per linear foot per foot of diameter to produce a 0.01-inch crack. The dead load to produce 0.01-inch crack as desired by the ASTM C76-2003, or its latest version shall be 1000 lbs force per linear foot per foot of diameter.

D) Crushing Load Test

- The crushing load test on the manufactured pipe shall be conducted in compliance with ASTM C76-2003, or its latest version; and
- Test load as desired by the specification shall be 1,500 lbs force per linear foot per foot of diameter.

E) Marking

The following information shall be marked on each pipe:

- Pipe class and specification designation;
- Name or trade mark of the manufacturer; and
- Identification of plants.

The Contractor shall bear the cost of such tests and pay fees etc., and also pay for the carriage of such samples and all other expenses contingent to tests. The manufacture of the pipes at the factory shall be watched and tested by the authorized representative of the Engineer.

32.2.4 Materials

All materials used in the manufacture of reinforced cement concrete pipes for use under this contract shall conform to ASTM C76-2003, or its latest version, and also with the following specifications:

A) Cement

The Portland cement which is required to be used in the manufacture of reinforced concrete pipes to be furnished and installed under this contract shall conform to the requirements of ASTM Designation C-150 latest revision.

B) Aggregate

The course/fine aggregate to be used in the manufacture of concrete pipes to be furnished and installed under this contract shall be generally in accordance with the provisions of section of these specifications.

C) Steel Reinforcement

The material will conform to the specifications contained in relevant Section of these specifications.

32.2.5 Mixing of Concrete

The proper types and amounts of Portland cement, mineral aggregates and water shall be thoroughly mixed in an approved type of mechanical batch mixer which shall be kept in first class condition. Admixtures in the concrete will not be permitted.

32.2.6 Pipe Dimensions

The internal diameters and wall thickness of reinforced concrete pipes under this contract shall be as set forth in ASTM C76-2003, or its latest version, in Tables I through V for “Wall B” pipe as required and shown on the Drawings.

The lengths of reinforced concrete pipes under this contract shall be as required to provide the designated laying length shall be in full, and shall not be less than 6 feet, nor more than 8 feet, unless otherwise approved in writing by the Engineer. Only one laying length shall be permitted for each size of reinforced concrete pipe under this contract and pipes not of the approved uniform laying length shall not be used in the work.

32.2.7 Lift Holes not permitted

Lift holes in the walls of reinforced cement concrete pipes will not be permitted under this contract for the purpose of handling and laying. Other approved lifting methods shall be employed.

32.3 CERTIFIED PLANS AND DATA SHEETS

The Contractor shall submit in triplicate, for approval by the Engineer, certified plans and data sheets as required to provide complete information on all

concrete sewer pipes, dimensions, type and dimensions of pipe ends, joint details, proposed concrete design mix for each different strength class of reinforced or non-reinforced concrete pipe and any other information needed to demonstrate full compliance with these specifications.

No concrete sewer pipe shall be delivered to the work site until the Engineer has formally approved the plans and data sheets and until all test requirements called for in the respective ASTM Standard Specifications ASTM C76-2003, or its latest version, and C-14 have been met.

32.4 JOINTS FOR CONCRETE PIPE SEWERS

32.4.1 General

Joints for concrete sewer pipes of more than 150mm diameter shall be Rubber Gasket joints as provided in the Drawings. No other types of joints will be permitted under this contract. For pipes of 150mm internal diameters collar joints will be used.

32.4.2 Rubber Gasket Joints

Rubber gasket joints shall be used for either tongue and groove or bell & spigot pipes.

Rubber gasket joints shall be made using specially designed rubber gaskets, made to fit the applicable tongue and groove or bell and spigot pipes and adequately tested under operating conditions. Special care must be taken in the selection and handling of the concrete pipes for use with rubber gasket joints, to ensure that pipe ends shall be smooth and concentric with tolerance which closely conforms to the requirements of the manufacturer of the rubber gaskets. The tongue or spigot end of each pipe shall be specially designed to perform groove or offsets to fit the manufacturer's rubber gasket design.

The rubber gasket joints shall conform to all applicable requirements of the latest revision of ASTM Designation C-443, entitled "Joints for Circular Concrete Sewer and Culvert Pipe, using Flexible Watertight Rubber Type Gaskets", except that the test pressure need not exceed 10 feet of head at which the completed sewers shall meet the infiltration or exfiltration limits set forth hereinafter.

The groove end of tongue and groove pipes of either the reinforced or non-reinforced concrete type, shall have at least one line of wire reinforcing of 8-gauge size placed in the centre of the groove.

The rubber gasket shall be installed on the pipe in accordance with the instructions of the gasket manufacturer. In general, the gaskets shall be pre-assembled to the pipe at the pipe manufacturing plant. The pipes shall be handled with special care at all times to prevent damage to the pipe ends.

A lubricant shall be used for jointing the pipes as recommended by the rubber gasket manufacturer. Care shall be taken to avoid contamination of the gasket and lubricated surfaces with earth or other undesirable material during installation.

For either tongue and groove or bell and spigot pipes, mechanical means shall be used to pull the pipe home for all sizes of 12-inch or larger diameter in accordance with the recommendations of the rubber gasket manufacture. Pipes of 9 inch or smaller diameter may be coupled manually using a cross member and bar. Under no circumstances will bars alone be used nor shall any motor driven equipment be used to force the pipe home.

32.5 INSTALLATION OF CONCRETE PIPE SEWERS

32.5.1 Handling of Pipes

Concrete sewer pipes shall be handled with special care at all times during the manufacture, while transporting to the site of work, and while installing. Each pipe shall be carefully inspected before being laid and no cracked, broken or defective pipe shall be used in the work. Chipping of the tongue and groove or bell and spigot pipe ends, which in the Engineer's opinion may cause defective joints, shall be sufficient cause for the rejection of any concrete pipe.

32.5.2 Excavation and Backfill

The excavation and backfill for sewer installations shall be as specified in applicable provisions of these technical specifications and will be paid for under separate contract items as classified.

32.5.3 Trench Bedding

Wherever called for on the Drawings or where ordered in writing by the Engineer, the Contractor shall furnish and place bedding, and/or concrete encasement for the concrete pipe sewers under this contract. The bedding shall be as specified in applicable provisions of these technical specifications and will be paid for under separate contract item as classified, described and listed in the Bill of Quantities or and as called for in applicable variation order.

The concrete encasement shall be placed in accordance with the details and notations on the Drawings or as ordered in writing. Concrete work shall be as specified in applicable provisions of Item of these technical specifications and will be paid for under separate contract items as classified, described and listed in the Bill of Quantities or as called for in applicable variation orders.

32.5.4 Laying of Sewers

Neither any sewer pipe nor the bedding shall be laid or placed till the

alignment of the sewer and its levels nor have gradients been carefully checked and tested with the trench excavation and found correct.

Each length of sewer pipe shall be checked for cracks and defects before placing in the line. Defects which in the opinion of the Engineer indicate imperfect placing, shall make the pipe liable to rejection. Each pipe shall be placed carefully to line and grade and in close contact with adjoining pipe. These specifications require rejection of the work if the sewer invert varies as much as 12mm from the proper elevation. As shown on Drawings, the bottom of the trench must be shaped to fit the pipe barrel, with holes left for the bells. If excavation has been carried below the correct grade, refilling must be done with satisfactory materials as approved by the Engineer at no extra cost.

The concrete pipe joints shall be of the types designated above and shall be made in accordance with the aforesaid specifications.

When laying is not in progress, the open pipe shall be closed with a tapered wooden plug to keep out foreign matter.

32.5.5 Pavement Restoration

The contractor shall restore paved surfaces which have been cut under this contract, as part of the work under the excavation items and at no extra cost to the Owner.

32.6 TESTS FOR INFILTRATION OR EXFILTRATION

32.6.1 General

All pipes built under this contract shall be tested for infiltration or exfiltration as specified below. The Contractor shall furnish labour, materials and equipment required for making the tests with no extra compensation over and above the agreed contract price for the sewers. The tests shall be made at times selected or approved by the Engineer. Sections of the completed sewer shall be isolated and measurements of the infiltration or exfiltration shall be made by approved methods.

32.6.2 Infiltration Tests

The sewers which are constructed with the ground water level above the crown of the pipe shall be tested for infiltration after the sewers have been installed and backfilling has been substantially completed. The tests and measurement shall be performed by the Contractor in the presence of and in a manner approved by the Engineer. The duration of the tests shall be only long enough to establish the true rate of infiltration. The amount of leakage over a 24 hours period will then be calculated from the result of the measured true rate of infiltration.

32.6.3 Exfiltration Tests

The sewers which are constructed with the ground water level below the crown of the pipe shall be tested for exfiltration by isolating a section of sewers between manholes by means of approved temporary type of water tight bulk heads. The method of testing for exfiltration shall be generally as follows:

- a. After isolation of sewer section, it shall be filled with water to a level which is 1m above the crown of the sewer at the higher end of the isolated section under test. The level will not be more than 6 feet above the crown of the sewer pipe at its lower end.
- b. The duration of the exfiltration test shall be one hour after the filling with water has been completed.
- c. Determination of the amount of exfiltration shall be made by measuring the total loss of volume of water in the manholes.
- d. The amount of exfiltration over a 24 hours period will then be calculated from the measured loss of volume during the test observation period.

32.6.4 Allowable Infiltration or Exfiltration

The calculated amount of infiltration or exfiltration over a 24 hours period shall not exceed 75 litre per mm of pipe diameter per km of sewer, which rate shall be applied to the actual sewer size and length tested to determine the allowable infiltration or exfiltration over the 24 hours period.

If the measured infiltration or exfiltration exceeds the specified allowable limit, then the Contractor shall locate the points of leakage and make necessary repairs so as to reduce the leakage to less than permissible maximum stated above.

32.7 MEASUREMENT AND PAYMENT

32.7.1 Measurement

Measurement for reinforced cement concrete pipes shall be made for the actual quantity of the work done in linear metre or linear feet (whichever is included in Bill of Quantities) of different sizes and strength installed tested and approved as authorized for payment under the Contract. The measurement will be made along the centre line of the pipe and between the inside walls of manholes or junction chambers.

32.7.2 Payment

The unit rate quoted in the Bill of Quantities for supplying, laying and jointing cement concrete sewer pipes, will be considered full compensation for the cost of pipes, charges for their carriage to site and testing before and after

laying, labour charges for laying, jointing, etc. and cost of all incidentals for completion of this item of work as per specifications laid down in this section. Payment for this item of work shall be made at the unit rate(s) quoted in the Bill of Quantities for various internal diameters of pipes.

SECTION - 33: PIPE BEDDING

33.1 SCOPE OF WORK

Wherever specifically called for by means of notes on the contract Drawings or by written order of the Engineer, the Contractor shall furnish and place sand or gravel/crushed stone bedding under sewer lines, drain pipes and other structures as a separate item of payment.

33.2 SOURCE OF BEDDING MATERIAL

Sand and gravel/crushed stone bedding material shall be from a source and of specifications approved by the Engineer.

33.3 PURITY AND STACKING

The sand and gravel/crushed stone shall be free from clay, salt, alkali, organic matter, shale, loam, soft flaky particles and other deleterious substances. It shall be stacked at the place designated by the Engineer and kept free from the admixture of deleterious materials mentioned herein. The sand shall have clay/silt contents not more than 5%.

33.4 PLACING OF BEDDING MATERIAL

The material for bedding shall be placed to the specified thickness and compacted by rammers of approved weight.

33.5 MEASUREMENT AND PAYMENT

33.5.1 Measurement

The measurement shall be made by volume for the actual quantity of the work done and the unit of measurement shall be cubic foot or cubic metre (whichever is included in Bill of Quantities).

33.5.2 Payment

Payment for this item of work shall be made for the actual quantity of work done as specified in this section, at the unit rate quoted in the Bill of Quantities.

PART - 8: CIVIL WORKS

SECTION - 34: EXCAVATION, BACKFILLING & DISPOSAL

34.1 SCOPE OF WORK

The work under this section consists of excavating, in all types of soil, lifting, transportation and disposal of the excavated material, back-fill and fill for building foundations, and under floors including all incidental work necessary for excavation to the required depth and dimensions and in accordance with the Drawings or as directed. The work shall be carried out in complete conformity with the specifications set-forth hereunder.

34.2 AUTHORIZED OUTLINES

Unless otherwise specified or directed in writing, all earthwork, i.e., excavation of trenches, pits, etc. for foundations, filling under floors, etc. shall be executed to the widths, depths, lengths, alignments grades and levels shown on the Drawings. If they are not indicated on the Drawings then the Contractor shall prepare the drawing showing the existing ground levels and the actual grades and levels of excavation for obtaining necessary approval from Engineer before excavating the ground.

Similarly, for all backfill and fill works the Contractor shall prepare drawings showing the existing ground levels and the actual finished level to ascertain the volume of fill for obtaining approval before the commencement of work.

34.3 CONSTRUCTION REQUIREMENTS

34.3.1 Excavation

A) General

All excavation, in any kind of soil encountered, shall be performed to the depths and widths indicated or as otherwise specified by the Engineer. During excavation, material suitable for backfilling shall be stockpiled in an orderly manner at a sufficient distance from the banks of the excavation to avoid overloading and to prevent sides from caving. Topsoil shall be stockpiled separately, for subsequent re-use as necessary. All excavated material unsuitable or not required for backfilling shall be removed and collected at a location approved by the Engineer.

It is anticipated that all excavation work under this Contract, will be earth excavation. The term “earth” as used herein shall include all materials which do not in the opinion of the Engineer, require blasting, barring or wedging of material for removal from its original bed.

Unless otherwise indicated or approved by the Engineer, excavation shall be open cut.

B) Timbering or Sheeting

The Contractor shall provide adequate timbering or sheeting for excavation where necessary, as part of the excavation work, to hold up the sides and ends of all excavations. Should the sides and ends of any excavation give away, the Contractor shall, at no extra cost to the Employer reinstate all disturbed ground.

If ordinary open-cut excavation is not possible or advisable, sheeting and bracing shall be furnished and installed in excavations generally in accordance with the details shown on Drawings to provide safe working conditions. The Contractor shall furnish and place all sheeting walls, braces, timbers, and similar items, necessary for the safety of the work, the general public and adjacent property. Sheeting and bracing shall be removed, as the work progresses in such manner as to prevent damage to finished work and adjacent structures and property. As soon as it is withdrawn, all voids left by the sheeting and bracing shall be carefully filled with selected material and compacted. The Contractor shall be fully responsible for the safety of work in progress, for the finished work, the workmen, the public and adjacent property. All sheeting and bracing shall be at the Contractor's expense, as part of the work under the excavation items and at no extra cost to the Employer.

The Engineer may order, in writing, any or all shoring, sheeting and piling to be left in place for safety reasons, whether such sheeting is shown on Drawings or not. If left in place, such sheeting shall be cut of at the elevation approved by the Engineer, and shall be paid separately.

C) Inspection of Foundations

When excavation up to foundation level is reached, as per Drawings, it is inspected by the Engineer and approved before start of any permanent construction. If safe foundation could not be obtained at the depth shown on the Drawings or at maximum depth of five feet below the ground level, the work shall be carried out as directed by the Engineer. Additional cost, if any approved by the Engineer, shall be paid in accordance with the provisions of the Conditions of Contract.

D) Disposal of Unsuitable/Surplus Materials

The unsuitable /surplus earth shall not be heaped within 5-feet of the top edge of any foundation. All surplus material excavated by the Contractor shall be disposed of at locations approved by the Engineer. The method of disposal shall not interfere with other works and shall not damage or spoil other materials. When it is necessary to haul earth material over streets or pavements, the Contractor shall prevent such material from falling on the streets or pavements. The surplus material shall be disposed-of within the site without any additional cost.

E) Excavation to be kept Free of Water

All excavations shall be kept free from water from whatever source it may come, at all times, except where otherwise specified or permitted in writing by the Engineer.

As part of the works, under the excavation items, and at no extra cost to the Employer, the Contractor shall build all drains and do ditching, pumping, well pointing, bailing and other work necessary to keep the excavation clear of ground, sewage or storm water during the progress of the work and until the finished work is safe from injury. The Contractor shall provide all necessary pumping equipment for the dewatering works as well as operating personnel, maintenance, power etc. all at no extra cost to the Employer. All water pumped or drained from the work shall be disposed of in a manner satisfactory to the Engineer. Necessary precautions against flooding shall be taken.

F) Safety Measures

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

The Contractor shall take special precautionary and protective measures with existing subsurface facilities likely to be encountered during the execution of works such as sewers, drain pipes, water mains, conduits, electric cables, communication cables, foundations of adjacent structures etc. As part of the works, the Contractor shall shore up all buildings, walls, poles and other structures, the stability of which is liable to be endangered by the execution of the works. The Contractor shall be responsible for damage to any such facility and shall repair the same at his expense whether or not this facility has been shown on the Drawings.

G) Excess Excavation

In the event of any excavation being carried out wider or deeper than shown on the Drawings, it shall be filled in by the Contractor at his own expense to meet the required dimension and levels with concrete or any other material approved for such purpose.

The bottom and side slopes of excavation upon or against which structures or other required constructions are to be placed shall be finished accurately to the required grades and dimensions and, if required, shall be moistened with water and tamped or rolled with suitable tools or equipment for the purpose of forming firm foundation. Whenever the natural foundation material is disturbed or loosened or excavated beyond the approved lines and grades the loose material shall be removed and the extra excavation made good at Contractor's expense with selected materials which shall be

thoroughly compacted by tamping rolling in layers not exceeding 6-inch.

H) Classification of Material

No classification will be made for payment purposes of any material excavated as to its class, nature, origin or condition, unless an unusual obstruction or embedded matter or substance is encountered. If this occurs, it shall be submitted by the Contractor for evaluation of design and working out of a necessary treatment. New items shall be mutually agreed.

I) Transportation of Materials

All carts, trucks or other vehicles used by the Contractor for transportation of the material shall be suitably constructed or lined out to permit any leakage of soil while the vehicles are on the move. These would be so loaded and arranged as not to spill on the site and public roads. Whenever any vehicle so used is found leaking and unsuitable it shall be immediately withdrawn from the work.

J) Termite Control

The approved foundation trenches shall be treated with the termite control solution.

34.3.2 Compacted Backfill

A) Excavated Earth for Backfilling

All fill or refill around structures, i.e., within the slopes and limits of the established lines for excavation for the structures and below the natural surface level, shall be defined as "Back Filling".

Backfilling operations for structure shall be performed as part of Contractor's work under the payment items for earth excavation, and at no extra cost to the Employer. It comprises returning, transportation and filling the selected excavated material around foundations, and at back of walls etc., up to finished levels shown on the Drawings or as required in layers not exceeding 6 inches carefully rammed and consolidated (with addition of water if required) so as to achieve a maximum density of 90%. The backfilling earth shall be free from stones and hard clods, larger than 3 inches in any dimension and also free from trash, lumber and other debris.

No backfilling shall be made until the concrete foundations and footings etc. have been inspected and approved. Earth to be used for filling must be free of all the organic impurities, debris or any other foreign matter. Earth which contains more than 1% of salts, particularly sulphates, will not be used in filling.

Testing shall be performed using the calibrated sand cone method to determine the density of soil in place. If soil in place fails to meet the specified degree of compaction it shall be removed, replaced with approved material and compacted to the specified density in the manner directed by the

Engineer, in the areas represented by the failing tests at no additional cost to the Employer.

B) Borrow Earth for Backfilling

In case of non-sufficiency of excavated material and unsuitability of earth for back-filling, appropriate material conforming to these specifications shall be brought by the Contractor.

Where satisfactory materials for backfill are not available in sufficient quantity from required excavation, “Earth Borrow” shall be obtained from suitable sources at the Contractor’s responsibility as a separate payment item. The necessary clearing and grubbing of borrow areas, disposal and burning of debris there from the developing of sources including any access roads for hauling and the necessary right-of-way, and the satisfactory drainage of the borrow areas, shall be considered as incidental items to borrow excavation. “Earth Borrow” under this separate payment item shall be furnished and placed by the Contractor only where specifically called for by the Engineer.

Filling shall be approved selected material from excavated or other predominantly granular material, free from slurry and organic or other unsuitable matter and capable of compaction by ordinary means

C) Sand Backfill

Special sand backfill is to be provided when specifically required by the Drawings or when ordered in writing by the Engineer. This work shall consist of removal of the excavated material to waste and provision in lieu of graded clean and fill, free of all foreign matter, such that 100% passes a ¾" screen with not more than 5% passing a No.4 sieve. This shall be compacted to 95% of the maximum density as determined by AASHTO T 180, Method D.

34.3.3 Filling Under Floors

A) Earth Filling

All fill or refill (from the excavated earth at site) about structures, i.e., above the natural surface level shall be defined as "filling under floors or embankment from excavated earth".

After the masonry has been laid up to the plinth level and the Damp Concrete Proof Course, if required is laid the space between the walls shall be cleared of debris and loose earth shall be laid in layers of 6-inch and each layer watered and compacted until the filling is completed up to the base level of the floor as shown on the Drawings. Only sandy soil free from salt peter either from the materials excavated from the foundations if such materials is suitable and sufficient or suitable material brought from outside shall be used.

B) Sand Filling

All fill or refill, from the material provided and brought from outside the site (any lead), about structures, i.e., above the natural surface level shall be defined as "filling under floors with earth provided and brought from outside".

Unless otherwise specified the base of all ground floors shall be constructed through sand filling, done in layers not more than 4-inch thick and shall be rammed after saturation to such an extent that 4-inch layer is reduced to about 2.7" after compaction.

The required in situ density with respect to maximum density to optimum moisture content shall be in compliance with test 12 of B.S. 1377-1967.

Sand shall conform in all respect to the specifications for fine aggregate except for its grading, i.e., it shall pass through a sieve No. 16 and not more than 30% shall pass through a sieve No. 100.

34.4 MEASUREMENT AND PAYMENT

34.4.1 Measurement

The measurement shall be made in cubic feet or cubic metre (whichever is included in Bill of Quantities) of earth acceptably excavated and backfilled for trenches and structures within the lines and grades shown on the drawing or as directed by the Engineer duly compacted as required. The measurement of dewatering in trenches or structures shall be not be made and cost of this item shall be deemed included in the cost of excavation, backfilling and compaction.

Any excavation carried beyond the limits shown on the Drawings and specified herein as the payment limits, shall be treated as excess excavation and shall not be measured for payment.

34.4.2 Payment

Payment for this item of work shall be made for the actual quantity of work done as specified in this section, at the unit rate quoted in the Bill of Quantities.

Filling under floors from excavated earth or borrowed sand shall be measured and paid separates as per respected items included in the Bill of Quantities

SECTION - 35: PLAIN & REINFORCED CONCRETE

35.1 SCOPE OF WORK

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, manufacturers, transporting, placing, consolidating and curing of plain & reinforced concrete and its constituents. Reinforcing steel does not form part of this section and is described in Section - 36:.

35.2 APPLICABLE STANDARDS

The work shall conform to requirements of latest editions of following standards, wherever applicable, unless otherwise specified.

35.2.1 Pakistan Standards

- 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 aggregate
- PS 282, Material finer than No. 200 PS test sieve in aggregates
- 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
- 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
- PS 717, Compacting factor test for concrete
- PS 746, Definitions and terminology of cements
- PS 849, Making and curing concrete compression test cubes

35.2.2 ASTM (American Society for Testing and Materials)

- ASTM C 33, Concrete Aggregates
- ASTM C 39, Test Method for Compressive Strength of Cylindrical Concrete Specimens
- ASTM C 40, Organic impurities in sand for concrete
- ASTM C 87, Effect of organic impurities in fine aggregates on strength of mortar
- ASTM C 88, Soundness of aggregates
- ASTM C 94, Ready mixed Concrete
- ASTM C 109, Compressive strength of hydraulic cement mortars
- ASTM C 117, Material finer than No. 200 (0.075mm) sieve
- ASTM C 123, Light weight pieces in aggregates
- ASTM C125, Concrete and concrete aggregates
- ASTM C 127, Specific gravity and absorption of coarse aggregate
- ASTM C 128, Specific gravity and absorption of fine aggregate
- ASTM C 13, Resistance to abrasion of small size coarse aggregate
- ASTM C 136, Sieve or screen analysis of fine and coarse aggregate
- ASTM C 142, Clay lumps and friable particles in aggregates
- ASTM C 143, Slump of Portland Cement Concrete
- ASTM C 150, Portland cement
- ASTM C 156, Water retention by concrete curing material
- ASTM C 171, Sheet material for curing concrete
- ASTM C 185, Air content or hydraulic cement mortar
- ASTM C 188, Density of hydraulic cement
- ASTM C 191, Time of setting of hydraulic cement by vicat needle
- ASTM C 260, Air entraining admixture for concrete
- ASTM C 289, Potential reactivity of aggregate
- ASTM C 309, Liquid membrane forming compounds for curing concrete
- ASTM C 494, Chemical admixtures for concrete
- ASTM C 535, Resistance to abrasion of large size coarse aggregates
- ASTM C 75, Aggregate sampling
- ASTM C 994, Preformed expansion joint filler for concrete
- ASTM C 1190, Concrete joint sealer (hot poured elastic type)
- ASTM C 1715, Preformed expansion joint filler for concrete paving and structural concrete

- ASTM D 1850, Concrete joint sealer (cold application type)
- ASTM E11, Wire cloth sleeves for testing purposes
- ASTM E 96, Water vapour transmission of materials in sheet form
- ASTM E 154, Materials for use as vapour barrier under concrete slabs
- ASTM E 337, Relative humidity by wet and dry bulk psychrometer

35.2.3 ACI (American Concrete Institute)

- ACI 211, Recommended practice for selecting proportions for normal and heavy weight concrete
- ACI 214, Quality control charts
- ACI 301, Specifications for structural concrete for building
- ACI 304, Recommended practice for measuring, mixing, transporting and placing concrete
- ACI 305, Hot weather concreting
- ACI 308, Recommended practice for curing concrete
- ACI 309, Recommended practice for consolidation of concrete
- ACI 315, Manual of standard practice of detailing reinforcement concrete structure
- ACI 318, Building code requirement of reinforced concrete
- ACI 347, Recommended practice for concrete formwork

35.2.4 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, sand fillers
- BS 822, Concrete aggregates from natural sources
- BS 1881, Methods of testing concrete
- BS 3148, Tests for water for making concrete
- BS 3837, Expanded polystyrene boards
- BS 3869, Rigid expanded polyvinyl chloride for thermal insulation.
- BS 4027, Sulphate – resisting Portland cement
- CP 8110, Structural use of concrete
- OP 114, Structural use of reinforced concrete in buildings

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.

35.3 SUBMITTALS

Suitable templates or instructions or both shall be provided for setting out of 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.

For special concrete finish and for special methods of construction, 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.

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.

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.

Where doubt exists as to the suitability of the water, it shall be tested in accordance with BS 3148.

The Contractor shall provide Mix design by weight for each class of concrete. Manufacture 12 test cylinder for each 3 mix design batches (6 Dia. x 12 high) inches in accordance with the Mix design batching by weight and test 3 cylinders each at 3, 7, 14 & 28 days intervals in the presence of Engineers 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.

'Workability' of Concrete 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 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.

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

The Contractor shall, at his own cost, make optimum mix design and testing for approval of the composition of non-shrinking grout and non-shrink second stage Concrete Grout, prior to Commencement of the work.

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. The proposal for transporting and erecting pre-cast units in position shall also be submitted by the Contractor for the approval of the Engineer.

All submittals shall be made as per the requirements of relevant section.

35.4 MATERIAL REQUIREMENTS

35.4.1 Aggregates

The sources of supply of all fine and coarse aggregates shall be as specified or approved by the Engineer.

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. They shall be placed on sloped hard strata to ensure well drained at all times.

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.

Coarse aggregate shall be 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 included in Table 35.1, for use in mass concrete as in foundations.

Table 35.1, Gradation Requirements for Coarse Aggregate in Mass Concrete

Sr. No.	BS Sieve	Percent Passing by Weight
1	3-inch (76.20mm)	100
2	1.5-inch (38.10mm)	95-100
3	0.75-inch (19.05mm)	30-70
4	0.37-inch (9.52mm)	10-35
5	0.19-inch (4.76mm)	0-5

Coarse aggregate for all cast-in-place concrete other than mass concrete, as for foundations, shall be graded with the limits as included in Table 35.2.

Table 35.2, Gradation Requirements for Coarse Aggregate in other than Mass Concrete

Sr. No.	BS Sieve	Percent Passing by Weight
1	1.5-inch (38.10mm)	100
2	0.75-inch (19.05mm)	95-100
3	0.37-inch (9.52mm)	25-55
4	0.19-inch (4.76mm)	0-10

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, as approved by the Engineer.

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-inch 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 stockpiled 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.

35.4.2 Cement

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 cement complying with the requirements of PS 232 or BS 12 or ASTM C-150.

Sulphate Resisting Portland/Cement complying with the requirements of P.S.612 or BS 4027 or ASTM C-150.

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

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.

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.

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.

There shall be sufficient cement at site to ensure that each section of work is completed without interruption. If the cement is supplied by the Employer, the Contractor should inform the Employer, of his requirements sufficiently in advance of its use in construction.

Cement reclaimed from cleaning of bags or from leaky containers shall not be used.

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.

The 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.

The mixing together of different types of cement will not be permitted.

35.4.3 Water

Water shall be tested in accordance with PS 3148 and shall be used only from an approved source.

The Contractor shall supply sufficient water for all purposes, including mixing the concrete, curing and cleaning plant and tools. 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.

35.4.4 Additive

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

Air Entraining Admixtures conforming to ASTM C-260, and other Admixtures conforming to ASTM C-494 shall be used subject to approval of the Engineer.

35.4.5 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:

- 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 aluminium powder containing non-polishing agent.
- 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.
- The above-specified composition may be varied if required by the Engineer.
- Proportioning shall be done by weight.
- Mixing water shall be proportioned so as to provide a flow able mixture without segregation or bleeding. Dry packing will not be permitted.

35.4.6 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 aluminium powder containing non-polishing agent. Proportioning shall be done by weight.

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

35.4.7 Non-Shrink Concrete Grout for Stair Railing Column Post

Grout for placement in pockets for stair columns shall be non-shrink and shall be of strength 10,000 psi.

35.5 NOMINAL CONCRETE MIXES

35.5.1 Proportions of Mix

Cement and aggregates

The 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 35.3.

The Contractor shall prepare mix design of various grades of concrete for the approval of Engineer prior to starting concrete works. He shall regulate and arrange mixing of the ingredients of the concrete by weigh batching. The cost of designing the mix shall be borne by the Contractor.

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.

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 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 and 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 if consolidation is to be by vibration. A tolerance of up to 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, whichever is fewer, does not exceed the maximum limit. Concrete of lower than usual slump may be used provided it is properly placed and consolidated.

35.5.2 Strength requirements for concrete

Concrete made with Portland cement shall comply with the strength requirements as included in Table 35.3.

Table 35.3, Strength Requirements for Portland Cement Concrete

Sr. No.	Concrete Class	Nominal Ratio*	Concrete Strength**
1	A	1:1:2	4500
2	B (or A3)	1:1.5:3	4000
3	C (or A1)	1:2:4	3000
4	D	1:3:6	2200
5	E (Lean Concrete)	1:4:8	1400

* Nominal Ratio is indicative only, Contractor to prepare mix design to achieve the cylinder strength for the corresponding class of concrete.

** Cylinder strength at 28-days after mixing and pouring in psi.

The strengths given in Table 35.3 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 cylinders may be tested at the equivalent maturity.

All structural concrete shall conform to BS 5328.

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 cylinders (6-inch diameter x 12-inch height) 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 made. The Contractor shall include this cost in the relevant item of concrete.

35.6 DELIVERY, STORAGE AND HANDLING

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 stockpiled 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 Contractor shall provide and erect (at his cost) a suitable plain, dry, well ventilated, weatherproof and water proof shed of sufficient capacity to store the cement.

35.7 CAST-IN-SITU CONCRETE

35.7.1 Batching

All cement, including cement supplied in bulk, shall be batched by weight. A bag of cement may be taken as 110 lbs. with the prior approval of the Engineer.

Aggregates shall be batched by weight, due allowance being made for moisture content. The apparatus for weigh-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 month.

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.

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.

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.

35.7.2 Mixing

The concrete shall be mixed in an approved batch mixer conforming to the requirements of BS 305. 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.

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 1½ minute, the Engineer's approval shall be obtained in writing.

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.

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.

Concrete shall be mixed only in quantities for immediate use. Concrete which has set shall not be re-tempered, but shall be discarded.

35.7.3 Transporting

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 or addition to ingredients it shall be deposited as nearly as practicable in its final position so as to avoid re-handling or flowing. All skips vehicles, or containers used for transporting the concrete shall be thoroughly clean.

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.

35.7.4 Placing

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

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.

Concrete shall be deposited continuously, or in layer 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.

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.

The concrete shall be placed as soon after it has been mixed as 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 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; 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 does not exceed 45 minutes under any circumstances. Any concrete which does not satisfy this requirement shall not be used.

The concrete shall be deposited as nearly as possible in its final position to avoid re-handling. 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.

The free fall of concrete shall not be allowed to exceed 5 ft. (1.5 m) and 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 (225mm) diameter.

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.

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, smooth, level surface using cement sand mortar in the ratio of 1-part of cement to 3-parts of sand. Two layers of building paper will then be laid flat to separate the concrete from the surface on which it is to be laid.

35.7.5 Construction Joints

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

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 not be at the underside of floor slabs or beams, and at the top of footings or floor slabs. Beams, brackets, columns, capital haunches and drop panels shall be placed at the same time as slabs. Joints shall be perpendicular to the main reinforcement.

All reinforcing steel shall be continued across joints. Key and inclined dowels shall be provided as directed by the Engineer. Longitudinal keys at least 1½-inch (40 mm) deep shall be provided in all joints in walls and between walls and slabs or footings.

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. Feather edges will be avoided.

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 unexposed walls and all others not mentioned herein shall be dampened (but not saturated) immediately prior to placing of fresh concrete.

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 150 mm thick on horizontal surfaces. The fresh concrete shall be placed before the grout has attained initial set.

Where the concrete has not fully hardened, all laitance shall be removed by scrubbing the wet surface with wire or bristles 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 (150 mm) in thickness, and shall be well rammed against old work, particular attention being paid to corners and closed spots.

35.7.6 Expansion Joints

Expansion joints shall be provided wherever indicated on the Drawings. In no case shall the reinforcement, corner protection angles, or other embedded items be run continuous or through an 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 as approved by the Engineer. All materials for use in the expansion joints shall have, prior approval of the Engineer before placing order for supply.

35.7.7 Embedded Items

The material, design and location of water stops in joints shall be as indicated in the Contract Documents. Each piece of re-moulded 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

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 50 mm and are spaced not less than three diameters on centres except when Drawings 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.

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.

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.

35.7.8 Mass Concrete

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

35.7.9 Consolidation

All concrete shall be consolidated by vibration, spading, Roding or forking so that the concrete is thoroughly worked around the reinforcement, around embedded items and into comers 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.

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 SECTION-35.5.

Vibrator shall not be allowed to contact the formwork for exposed concrete surfaces.

Mechanical vibrators shall be of a type suited in the opinion of the Engineer to the particular conditions.

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

35.7.10 Curing and Protection

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.

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; and
- 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.

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.

Curing in accordance with sub-clause 'a' & 'b' 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 cylinders 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 cylinder strength.

If one of the first four curing procedures of sub-clause 'b' 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.

When the mean daily outdoor temperature is less than 5 degree C (41 deg. F) temperature of the concrete shall be maintained between 14 and 20 degrees C (50 to 68 deg. F) for the required curing period of sub-clause 'd'.

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 gases, which contain carbon dioxide.

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.

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 14 degree C (50 deg. F) in any 24-hour period.

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.

35.7.11 Application of Non-Shrink Grout

Concrete surfaces to receive non-shrinking grout shall be roughened, cleaned and dampened.

Form shall be provided to retain the grout until sufficiently hard to support itself.

Grout shall be poured in place and thoroughly rodded or washed to prevent the formation of voids.

After non-shrink grout has received its initial set, it shall be kept damp for 24 hours.

35.7.12 Placing of Vapour Barrier

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.

35.8 WORKS IN EXTREME WEATHER

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

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

When the temperature of the surrounding air is expected to be below 5°C during placing or within 24 hours thereafter, the temperature of the plastic concrete, as placed, shall be no lower than 13°C for sections less than 12-inch in any dimension nor 10°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°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°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 & aggregate having a temperature greater than 38°C.

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°C. For massive concrete, this temperature should not exceed 21°C. When the temperature of the concrete exceeds 32°C, precautionary measures approved by the Engineer shall be put into effect. When the temperature of the steel is greater than 50°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 shall also be adopted.

35.9 PRECAST CONCRETE

Precast concrete units shall be fair faced, cast to the sizes and dimensions as indicated on the Drawings. The concrete used for precast 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 precast 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 precast units from the pre-casting platform shall not be permitted until and unless they are properly cured to the satisfaction of the Engineer.

All precast units shall be smoothly finished to the required lines, grades, angles etc. Holes, grooves, pockets, 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 precast units shall be done in accordance with the relevant BS/approval of the Engineer.

35.9.1 Erecting Precast Units

All the precast 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.

The units shall be embedded or otherwise installed in their permanent positions as shown on the Drawings or as directed by the Engineer.

35.9.2 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.

35.10 CEMENT CONCRETE PAVEMENTS

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

35.10.1 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 or shall be given two coats of nitro-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 shovelled into position. The spreading shall be carried out very carefully. Compaction shall be done by means of vibro-compactors or 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 trowelled 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 preformed groove shall provide complete separation of adjacent slabs. The joints shall all be sealed with bitumen as shown on the Drawings or/and as directed by the Engineer.

35.10.2 Protection and Curing

A) General Requirements

Concrete shall be protected adequately from injurious action 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 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 white coloured and shall be approved by the Engineer and shall comply with ASTM C 309, type 2.

B) Curing Periods

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

C) 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 damage during the removal of formwork and from injury resulting from the storage or movement of material during construction.

35.10.3 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 washed clean. Plastering of surface, application of cement or other coating will not be permitted.

All exposed corners shall be chamfered, 1-inch x 1-inch (25x25mm) unless otherwise mentioned or shown in the Drawings or directed by the Engineer. Concrete surface which will be covered with other materials shall be screeded without floating.

35.10.4 Spreading, Finishing and floating of concrete in pavements**A) 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.

B) 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 onto the finishing machine. Vibrators shall not

rest on new 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 Drawings 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.

C) Manual Methods

When striking-off and compacting by manual methods is permitted, the concrete shall be levelled 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 ends 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 light 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 cubic feet. After the concrete has been compacted, it shall be smoothed with a wooden float where necessary, as directed by the Engineer.

D) 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.

E) 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 re-floating shall continue until the pavement has the required surface contour.

F) 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 burl of 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.

G) 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.

35.10.5 Expansion and Contraction Joints

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 be sealed with the specified non-extruding sealing compound set in a 3/4-inch wide preformed chase as shown on the Drawings. The lie preformed chase shall be thoroughly cleaned of all dust, debris, stone 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.

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 flexell 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 - 36:, REINFORCEMENT.

A) 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.

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.

35.11 TEST OF CONCRETE QUALITY

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. 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 at site and tests carried out under his direct supervision.

Cylinder test shall be performed in accordance with the discretion of the Engineer. The standard of acceptance for preliminary and works tests shall be as given below,

The usual test for concrete with maximum size of aggregate up to 1-1/2 inch is the 6-inch cylinder tested in compression. Details of the testing are given in ASTM C 39.

For all grades of concrete; preliminary cylinder strength test with the mixes and materials to be used shall be performed in accordance with ASTM C 31 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 35.3 in accordance with ASTM C 39. The cost of such testing shall be borne by the Contractor.

Test sample shall be taken at the mixer or as directed by the Engineer. The test specimens shall be cured in accordance with ASTM C 31.

Records shall be kept of all test cylinders identifying the mix used the section of work for which the concrete was used and the date poured.

Five test cylinders are to be tested for compressive strength as specified in ASTM C 39. These tests shall be carried out at site or in a laboratory, approved by the Engineer. Two cylinders 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.

For all grades of concrete, the appropriate strength requirement shall be considered to be satisfied if none of the strengths of the cylinders is below the specified cylinder strength or if the average strength of the three cylinders is not less than the specified cylinder strength and the difference between the greatest and the least strength is not more than 20% of the average.

When the results of works cylinder 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 worst, 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.

35.12 FINISHING OF FORMED SURFACES

35.12.1 General

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.

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.

Allowable deviations from plumb or level and from the alignment, profile grades, and dimensions are specified in clause 9. Tolerances for concrete construction are defined as tolerances 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 section, 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 2 metre for testing of formed surfaces and 3 metre for testing of unformed surfaces.

35.12.2 As-cast Finishes

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

A) Rough form finish

No selected form facing materials shall be specified for rough form finish surfaces. The holes and defects shall be patched. Otherwise, surfaces shall be left with the texture imparted by the forms.

B) 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 as shown in the Drawings. Surface irregularities, measured as described in sub-clause 7.2.1, 'Rough form finish', shall not exceed 4 mm for gradual irregularities and 6mm for abrupt irregularities, except that abrupt irregularities will not be permitted at construction joints. Abrupt irregularities at construction joints and elsewhere in excess of 6 mm and gradual irregularities in excess of 1/8 inch. (3mm) 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. The holes and defects shall be patched. All fins shall be completely removed

C) 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 encrustations.

C.1 Sample approvals of precast & in-situ concrete

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

C.2 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. (20mm) 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 of the Engineer.

C.3 Curing

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

C.4 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 pit 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 C144. 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.

C.5 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.) 25gm of sodium citrate in (0.33lb) 150 gms 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.

C.6 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 approve 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 as 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.

C.7 Finishes of Unformed Surfaces

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 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.

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.

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.

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.

C.8 Tie and Bolt Holes

After being cleaned and thoroughly dampened, the tie and bolt holes shall be filled solid with patching mortar.

C.9 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.

35.13 TOLERANCES

Where tolerances are not stated in the 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 limits. These allowable tolerances shall not relieve the Contractor of the responsibility for correct fitting of indicated materials. Those tolerances are not cumulative.

A) Variation from the plumb (or the specified better for inclined walls)

A.1 In the lines and surfaces of columns, piers, and walls and in arises.

In any 10 ft. (3 metre) of length or height:	1/4" (6 mm)
In any storey or 20 ft. (6 metre) maximum:	3/8" (10 mm)
Maximum for the entire length or height:	1" (25 mm)

A.2 For exposed corner columns, control joint grooves and other conspicuous lines.

In any bay or 20 ft. (6 metre) maximum	1/4" (6 mm)
Maximum for the entire length or height	1/2" (13 mm)

B) Variation from the level or from the grades indicated on the Drawings.

B.1 In floors, ceilings, beams soffits and in arises.

In any 10 ft. (3 metre) of length	1/4" (6 mm)
In any bay or 20 ft. (6 metre) maximum	3/8" (10 mm)
Maximum for the entire length	3/4" (20 mm)

- B.2** *For exposed lintels, sills, parapets, horizontal grooves and other conspicuous lines.*
- | | |
|--|--------------|
| In any bay or 20 ft. (6 metre) maximum | 1/4" (6 mm) |
| Maximum for the entire length | 3/8" (10 mm) |
- C) Variation of the linear building lines from established position in plan and related position of columns, walls and partitions.**
- | | |
|--|--------------|
| In any bay or 10 ft. (3 metre) maximum | 1/2" (13 mm) |
| Maximum for the entire length | 1" (25 mm) |
- D) Variation in the sizes and locations of sleeves, Floor openings and wall openings.**
- ± 1/4" (± 6mm)
- E) Variation in cross-sectional dimensions of columns and beams and in the thickness of slabs and walls.**
- | | |
|-------|-------------|
| Minus | 1/4" (6mm) |
| Plus | 1/2" (13mm) |
- F) Footings**
- F.1 Variation in dimensions in plan Minus**
- | | |
|-------|--------------|
| Minus | 1/2" (13 mm) |
|-------|--------------|
- Plus (plus variation applied to concrete only, not to reinforcing bars or dowels). 2" (50mm)
- F.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" (15 mm)
- F.3 Thickness**
- | | |
|---------------------------------|----------|
| Decrease in specified thickness | 5% |
| Increase in specified thickness | No limit |
- G) Variation in Steps**
- G.1 In a flight of stairs**
- | | |
|-------|-------------|
| Rise | 1/8" (3 mm) |
| Tread | 1/4" (6 mm) |
- G.2 In consecutive steps:**
- | | |
|-------|----------------|
| Rise | 1/16" (1.5 mm) |
| Tread | 1/8" (3 mm) |

H) Tolerances for Pre-Cast Concrete Constructions

Forms must be true to size and dimensions of concrete members shown on the Drawings 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:

Overall dimensions of members	1/16" per 10 feet
Cross-sectional dimensions	
Sections less than 3-inch	1/16" (1.5 mm)
Sections over 3-inch and less than 18-inch	1/8" (3 mm)
Sections over 18-inch	1/4" (6 mm)
Deviations from straight line in long sections	
Not more than	1/8" per 10 feet
Deviation from specified camber	1/16" per 10 feet
Maximum differential between adjacent units in erected position	1/4" (6 mm)

35.14 ACCEPTANCE OF STRUCTURE

35.14.1 General

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

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.

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.

35.14.2 Dimensional Tolerances

Formed surfaces resulting in concrete outlines smaller than permitted by the tolerances of SECTION-35.13 shall be considered potentially deficient in strength and subject to the provisions of SECTION-35.14.4.

Formed surfaces resulting in concrete outlines larger than permitted by the tolerance of SECTION-35.13 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.

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.

Inaccurately formed concrete surfaces exceeding the limits of SECTION-35.13 which are exposed to view, may be rejected and shall be repaired or removed and replaced if required.

35.14.3 Appearance

Architectural concrete with surface defects exceeding the limitations shall be removed and replaced.

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

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

35.14.4 Strength of Structure

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 SECTION-35.5.2.
- 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 or premature removal of formwork likely to result in deficient strength.
- Poor workmanship likely to result in deficient strength.

Structural analysis and/or additional testing may be required when the strength of the structure is considered potentially deficient.

Core tests may be required when the strength of the concrete in place is considered potentially deficient.

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, CP 110 or ACI 318.

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.

The Contractor shall pay all costs incurred in providing the additional testing and/or analysis required by this section.

All costs of additional testing and/or analysis which is made at the Employer request and which is not required by these Specifications, or by the Contract Documents shall also be borne by the Contractor.

35.15 MEASUREMENT AND PAYMENT

35.15.1 Measurement

Concrete will be measured for the number of cubic foot or cubic metre (whichever is included in Bill of Quantities) acceptably placed complete in all respects as per Drawings and in strict accordance with this section of specification.

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 this 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:

- Providing, fixing, striking, etc. of formwork.
- Providing, placing and fixing of anchor bolts or any other embedded parts.
- Providing and installing all type of joints in concrete structure, including expansion joints.
- Providing and fixing water stoppers.

35.15.2 Payment

Payment will be made in accordance with the unit prices in the Bill of Quantities for the various items in accordance with the specifications and shall constitute full compensation for furnishing all materials, shuttering, equipment and labour and for performing all operation necessary to

complete the work.

Concrete shall be measured as executed but no deductions 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; and
- 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.

SECTION - 36: REINFORCEMENT

36.1 SCOPE OF WORK

The work under this section of specifications consists of furnishing, cutting, fabricating, bending and placing steel reinforcement as shown on the Drawings or as directed by the Engineer. The scope of this section of specification is covered with detailed specifications as laid down herein.

36.2 APPLICABLE STANDARDS

The work shall conform to requirements of latest editions of following standards, wherever applicable, unless otherwise specified.

36.2.1 Pakistan Standard

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

36.2.2 British Standard

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

36.2.3 ASTM Standard

- ASTM A 305, Minimum requirement for the deformations of deformed steel bars for concrete reinforcement
- ASTM A 615, Deformed billet steel bars for concrete reinforcement

36.2.4 ACI Standard

- ACI 315, Manual of standard practice for detailing reinforced concrete structure
- 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.

36.3 SUBMITTALS

The Contractor shall submit the following to the Engineer for approval before commencement of work:

- Bar bending schedule prepared by Contractor on the basis of approved Drawings for the approval of the Engineer.
- Results of all tests performed upon steel reinforcement bars obtained from the site of work as per directions of the Engineer.

36.4 MATERIAL REQUIREMENTS

Reinforcement for concrete shall conform to the respective Pakistan, British, ASTM, or other Standards as specified in the Drawings and in the Contract Documents or as may be specified by the Engineer.

Unless otherwise specified, all plain reinforcing bars shall comply with the requirements of BS 4449 for plain mild steel bars and shall have a minimum characteristic strength of 40,000 psi.

Unless otherwise specified, all deformed reinforcing bars shall comply with the requirements of BS 4461 for deformed cold worked new stock billet steel bars and shall have a minimum characteristic strength of 60,000 psi.

Steel wire mesh reinforcement shall conform to requirements of ASTM Designation A-185-64 or BS 4483. Standard Specifications for Welded Steel Wire Fabric for concrete reinforcement. It shall be used where shown on the Drawings.

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

36.5 DELIVERY & STORAGE

36.5.1 Delivery

Steel reinforcement bars shall be kept in bundles firmly secured and tagged.

36.5.2 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.

36.6 BAR BENDING SCHEDULES

The Contractor shall prepare bar bending schedules of all the reinforcing steel bars and these bar bending schedules shall be submitted to the Engineer for approval. The Contractor shall obtain approval of the bar bending schedules before starting actual bar bending works.

36.7 FABRICATING, BENDING & PLACING

All metal for reinforcement shall be free from loose mill scale, loose rust, mud, oil, grease, or other harmful matter immediately before the concrete is placed.

Reinforcement is to be accurately placed as shown in the Drawings, and secured against displacement by using 16-gauge G.I wire ties or suitable slips at intersections and supported from the formwork by using concrete, metal or plastic chairs and spacers or hangers of an approved pattern. Where concrete blocks are used for ensuring the cover, they shall be made of mortar not leaner than 1 part of cement to 2 parts of sand.

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.

Bars used for concrete reinforcement shall be fabricated in accordance with the dimensions shown in the bar bending schedule approved by the Engineer. The cutting tolerance for all bars shall be ± 1 inch. (± 25 mm).

Where an overall or an internal dimension of a bent bar is specified in the schedule, the bending tolerance, unless otherwise stated, shall be as included in Table 36.1.

Table 36.1, Bending Tolerances for Reinforcement Bars

Sr. No.	Dimension of Bent Bars		Tolerance	
	Over Feet	Up to & Including Feet	Plus Inch	Minus Inch
1	-	3	1/5	1/5
2	3	6	1/5	1/5
3	6	-	1/5	1

Bars shall be placed to the tolerances as included in Table 36.2.

Table 36.2, Placement Tolerances for Reinforcement Bars

Sr. No.	Location of Bars	Tolerance
1	Concrete cover to formed surfaces	$\pm 1/4"$ ($\pm 6\text{mm}$)
2	Minimum spacing between bars	$\pm 1/4"$ ($\pm 6\text{mm}$)
3	Top bars in slabs and beams	
	Members 8 inch deep or less	$\pm 1/4"$ ($\pm 6\text{mm}$)
	Members more than 8 inch but not over 24 inch deep	$\pm 3/8"$ ($\pm 10\text{mm}$)
	Members more than 24 inch deep	$\pm 1"$ ($\pm 25\text{mm}$)
4	Crosswise members spaced evenly within	$\pm 2"$ ($\pm 50\text{mm}$)
5	Lengthwise members	$\pm 2"$ ($\pm 50\text{mm}$)

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.

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

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.

No splice of reinforcement shall be made except as shown on the working Drawings.

Welding shall be permitted for, bars only under suitable conditions and with suitable safeguards in accordance with BS 693, PS 1856, or AWS D12.1, provided the type of reinforcement bar has the required welding properties. Tack welding may be used to fix in position bars that cross each other, only with prior approval of the Engineer.

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.

No concreting is to be carried out until the reinforcement has been checked and approved by the Engineer.

Welding shall be done as in section 'Structural Steel Works'. All detailing shall

be done as per ACI standards ACI-315 and ACI-318.

Concrete clear cover for reinforcing steel shall be as provided in Drawings. All reinforcing steel shall be held firmly in place before and during the placing of concrete by means of wires and supports adequate to prevent displacement during the course of construction.

36.8 MEASUREMENT & PAYMENT

36.8.1 Measurement

The measurement for acceptably completed works of reinforcement according to bar bending schedules approved by the Engineer shall be made by weight computed on the bases of Table 36.3.

The Contractor shall not claim for the difference in the actual weights of bars and their standard weights given in Table 36.3.

Table 36.3, Standards Weights of Reinforcement Bars

Sr. No.	Nominal Bar Diameter, Inch	Bar No.	Weight, lb/ft
1	3/8	#3	0.376
2	1/2	#4	0.668
3	5/8	#5	1.043
4	3/4	#6	1.502
5	7/8	#7	2.044
6	1	#8	2.670
7	1-1/8	#9	3.400
8	1-1/4	#10	4.303

The rates quoted by the Contractor in the Bill of Quantities shall include work to be executed under these specifications 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.

Providing and installing cover blocks, chairs, supports, hooks, spacers, binding wires, and laps not shown on Drawings including wastage and rolling margin and as such are not payable. Laps shown on Drawings shall be payable.

36.8.2 Payment

Payment will be made for acceptable measured quantity of reinforcement on the basis of unit rate per metric ton or kg (whichever is included in Bill of Quantities and shall constitute full compensation for all the works related to the item.

The rate quoted include all lead/lift required for steel fabrication & placement at/in any floor or at any height as per Drawings.

SECTION - 37: SULPHATE RESISTANT CEMENT CONCRETE

37.1 SCOPE OF WORK

This work shall consist of providing sulphate resistant cement in place of Portland cement to all classes of concrete subject to the contact with soil having sulphate content more than 0.1% and with ground water having sulphate content more than 1500 ppm or as mentioned in the drawing or directed by the Engineer. Maximum Chloride Ion Concentration (as a percentage of weight of cement) arising from all sources including aggregates should not exceed 0.1 for pre-stressed concrete, 0.2 for any concrete using sulphate resistance cement and 0.35 for all other cement containing matter. All requirements of concrete with sulphate resistant cement are same as mentioned in Section - 35: PLAIN & REINFORCED CONCRETE except amended in this section

37.2 MATERIAL REQUIREMENTS

Sulphate resistant cement where required shall be sulphate resistant cement type 'A' fully conforming to Pakistan standard specification PS 612:1967 and satisfying to requirements for fineness, chemical composition, strength, setting time and soundness etc. The average compressive strength of three mortar cubes prepared with 1:3 cement and standard silica sand mortar shall not be less than 20.0 N/mm sq. at seven days. The initial setting time shall not be less than 45 minutes and final setting time not more than 10 hours.

37.3 MEASUREMENT AND PAYMENT

37.3.1 Measurement

The quantity of concrete with sulphate resistant cement shall be measured exactly in same way as mentioned in Section - 35: PLAIN & REINFORCED CONCRETE and subsequently paid as elaborated below.

37.3.2 Payment

The accepted quantity measured as provided above shall be paid only for the difference of cost for providing sulphate resistant cement in place of ordinary Portland cement at the contract unit price for particular pay item(s) as provided in the Bill of Quantities, which price and payment shall be full compensation for all the costs involved in the proper completion of the works.

SECTION - 38: CEMENT PLASTER

38.1 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 in connection with providing and installation of cement plaster, and specified external rendering complete in strict accordance with this section of the specifications and the applicable Drawings and subject to the terms and conditions of the Contract.

38.2 APPLICABLE STANDARDS

The work shall conform to requirements of latest editions of following standards, wherever applicable, unless otherwise specified.

38.2.1 Pakistan Standard

- PS 232, Ordinary Portland Cement

38.2.2 ISO (International Organization for Standardization)

- R 597 Definitions and terminology of cement.
- R 679 Method of testing strength of cements, compressive and flexural strength of plastic mortar (Rilem - (embureau method).
- P 680 Chemical analysis of cement & main constituents of Portland Cement.
- R 681 Chemical analysis of cements-mixer Constituents of Portland cement.
- R 682 Chemical analysis of cements - determination of sulphur as sulphide.

38.2.3 ASTM (American Society for Testing and Material)

- ASTM C144, Aggregate for Masonry mortar
- ASTM C631, Bonding Compounds for interior plastering

38.2.4 BSI (British Standards Institution)

- BS 812, Methods for sampling and testing of mineral aggregates, sands and fillers.
- BS 1199, Sands for external renderings Internal plastering with lime and Portland cement and floor screeds.
- BS 1369, Metal lathing (steel) for plastering.
- BS 5262, External rendered finishes.
- BS 5492, Internal plastering.

38.3 SUBMITTALS

Sample of materials shall be submitted to the Engineer for his approval prior to use in the works.

38.4 MATERIAL REQUIREMENTS

Portland cement for mortar shall conform to the applicable requirements specified in the Section - 35:, PLAIN & REINFORCED CONCRETE.

Sand for plaster shall comply with the requirements of BS 1199, BS 1200 or the Pakistan Standard “Sand for Plaster” as directed by the Engineer.

Water for plaster shall conform to the applicable requirements specified in the Section - 35:, PLAIN & REINFORCED CONCRETE.

All materials and workmanship for plaster not explained in these specifications, shall comply with the requirements of relevant BS CP 211 and CP 221 or as directed by the Engineer.

38.5 PROPORTIONING AND MIXING

Except as may be otherwise shown on surfaces specified, all plaster work, both internal and external shall be Ordinary Portland Cement plaster of the required thickness and cement/sand ratio as shown on the Drawings.

Measurement of materials by volume shall be by containers of known capacity to maintain consistent proportions. No lumpy or caked material shall be used. Mixing equipment boxes and tools shall be clean. Materials shall be proportioned as specified on the Drawings or as directed by the Engineer. Mixing shall be continuous until all ingredients are evenly distributed and thoroughly mixed.

Only limited water shall be added for proper workability and such quantity of mortar shall be prepared which can be consumed in thirty minutes after preparation. Preparation of mortar in bulk quantity for use during the entire day or for any other time more than that stipulated above is expressly prohibited. Re-tempering shall not be permitted and all mortar which has begun to stiffen shall be discarded.

Plaster ingredients shall be thoroughly mixed either by hand on a clean cement concrete platform or by a mechanical mixer, as directed by the Engineer.

Additives for controlling the setting and working characteristics of plaster or for imparting anticorrosion, fungicidal or water proofing properties, shall be added to the plaster strictly in accordance with the particular manufacturer's written instructions. Good quality hair or manila fiber in reasonably well distributed proportion may be to the plaster to assist application and reduce droppings. No additives shall be used except as specified in the Contract Documents

38.6 PREPARATION OF SURFACE TO BE PLASTERED

Plastering shall not commence until all electric conduits, drainage and sanitary pipes, inlets to tanks, brackets, clamps, doors and window frames and all sorts of inserts and embedded items are fixed in position. It shall be the responsibility of the Contractor to make sure that all such work is carried out by other contractors before starting of plaster work. Chiselling and repairing of cement plaster shall not be permitted without the approval of the Engineer.

Concrete surface to be plastered shall be cleaned to remove all grease, form oil and other surface impurities which will otherwise adversely affect the adhesion of plaster to the surface concerned. The surface of all concrete ceilings, beams and columns shall be lightly hacked by approved means to give the required key for plastering.

All masonry surface to be plastered shall be cleaned to remove all matter which will otherwise adversely affect the adhesion of plaster to the surface concerned. The surface shall be washed with clean water and kept damp for 24 hours before further treatment, the surface thus prepared shall be treated uniformly with cement and sand slurry. The slurry to be used shall be one-part cement to one-part sand by volume with water added to make a stiff. Spatter dash of slurry shall be applied on surface to receive plaster and be left to cure for three days.

38.7 APPLICATION OF PLASTER

The plaster of a thickness less than the specified thickness shall be rejected. If the plaster is to be more than ½-inch thick, it shall be done in two coats. The surface of first coat shall be made rough before the second coat is applied. Plaster shall not have wavy surface and shall be perfectly in plumb. The edges and corners shall represent a straight line. The plaster shall be kept wet continuously for at least ten days. No extra payment shall be allowed for jambs, junctions, corners, edges, round surfaces or plaster required due to any unevenness in the work done by the Contractor. The plaster work is to cover all conduits, pipes etc. fixed in the walls and ceiling. Wherever specified, metal lath shall be nailed firmly before plastering is commenced. The plaster surface shall be tested frequently with a 10-foot straight edge and plumb bob.

Plaster containing cracks, blisters, pits, discolouration or any defects shall not be acceptable. Any plaster giving hollow sound or loose plaster shall be removed and replaced with plaster in conformity with these specifications and as additionally directed by the Engineer. Contractor shall cut out and patch all defective work at his own cost. All damaged plaster shall be patched as directed by the Engineer. Patching plaster shall match appearance of and shall be finished level with adjoining plaster.

38.8 METAL LATH

Before plastering, wherever brick masonry meets with reinforced concrete members, 6-inch wide continuous strip of expanded metal lath shall be nailed to the masonry and the reinforced concrete member covering the point completely to prevent cracking of the joint

Metal lathing shall be fabricated from sheet steel, and shall be of uniform quality and free from flaws broken strands, cracks and corrosive pitting, shall be rectangular and true to shape and shall comply with BS-1369.

All lathing shall be galvanized. Where plastering material depends entirely on the lathing for its key, these shall be not less than two complete mesh openings per 1.12-inch in one direction and the width of the aperture shall not be less than 0.2-inch.

Sheet shall be not less than 1.60 kg/m² when fabricated, using 0.7mm thick steel sheet. Where used on smooth surfaces to form a key, it shall be not less than 1.20 kg/m² when fabricated, using 0.5mm thick steel sheet. Typing wire shall be 1.2mm diameter galvanized annealed iron wire.

38.9 BEADS & PROFILES

Angle beads, corner beads, stop beads, architrave beads, depth gauge beads, edging profiles, plaster dividing profiles, interior angle profiles, plaster borders and the like shall all be manufactured from sheet steel and galvanized after fabrication, all beads & profiles shall be perforated at edges to ensure good adhesion of the plaster work. Thickness and dimensions shall suit particular locations and plaster work thickness.

Nails for fixing lathing shall be galvanized and have either clout heads or small flat heads to suit particular locations.

All angle beads, stop beads, architrave beads, depth gauge beads, and the like are to be fixed in accordance with the manufacturer's instructions.

38.10 CLEANING AND PROTECTION

Rubbish and debris shall be removed as necessary to make way for work of other trades and as directed by the Engineer. As each room or space is completed all rubbish, debris, scaffolding and tools should be removed to leave the room clean.

Prior to plastering, all doors/windows, finished metals etc. should be covered by sheet of plastic or tarpaulin to protect them from damage.

Protect finished, plaster from injury by any source. Contractor shall also protect walls, floors and work of other trades from plaster materials.

38.11 TOLERANCES

Surfaces of plaster work shall be finished with a true plane to correct line and level unless otherwise specified and with walls reveals plumb and square.

Maximum permitted tolerances shall not exceed 1/8-inch in 6-feet variation from plumb or level in any exposed line or surface and 1/16-inch variation between planes of abutting edges or ends.

38.12 POINTING WORK

Joints of masonry work to be pointed shall be properly raked to 1/2-inch depth, cleaned and wetted.

For struck pointing the mortar shall be filled in the joints flush with masonry with a pointing trowel and then pressed with proper pointing tools to form weathered and struck horizontal and triangular or V-notched vertical joints.

For flush pointing after pressing mortar in the joints these shall be tilled up with mortar and finished level with edges.

After pointing the face of the work shall be cleared of all surplus mortar. No washing shall be done till the pointing has set. All defects shall be treated at Contractor's expense. All work shall be kept wet for 10 days and protected from extreme temperatures and weather.

38.13 MEASUREMENT AND PAYMENT

38.13.1 Measurement

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 thereof shall be deemed to have been included in the quoted unit rate of the respective items of the Bill of Quantities.

- Metal lath over reinforced concrete and masonry joint.
- Joints, junctions, corners, drip course, edges and rounding.
- More than one layer due to any unevenness in the finished works.
- Cutting & patching of all defective works.
- Surface preparation, cleaning and protection as specified.
- Water proofing agent for water proof plaster.
- Angles beads, corner beads, stop beads, architrave beads, depth gauge edging profiles, plaster dividing profiles, interior angle profiles and plaster borders used in plaster works as shown on Drawings.

Measurement shall be made of cement plastering for the actual area in square feet or square metre (whichever is included in Bill of Quantities) in

accordance with this section of specification or as directed by the Engineer.

38.13.2 Payment

Payment shall be made for the number of square feet or square metre (whichever is included in Bill of Quantities) of surface area cement plastered at the contract unit price and shall constitute full compensation for furnishing all materials, equipment and labour including all incidentals necessary to complete the work in strict accordance with this section of specification.

SECTION - 39: BLOCK MASONRY

39.1 SCOPE OF WORK

This section consists of construction of brick/ cement concrete block work walls of any thickness with first class hand-mould and/or machine pressed bricks/cement concrete blocks with the specified ratio of cement mortar in foundation, plinth superstructure or for any other structure as directed by the Engineer, or shown in the Bid Schedule. The Contractor shall furnish all materials and all other requirements to produce finished brick/block work. Brick/block work and materials for brick/block work shall be in strict accordance with this section of the specifications and applicable drawings and subject to the terms and conditions of the Contract.

39.2 MATERIALS

39.2.1 Portland Cement

Portland cement shall conform to the stipulations and requirements set forth in Section "CONCRETE".

39.2.2 Mortar Sand

Sand for mortar used in construction of brickwork/blockwork required under these Specifications shall be furnished by the Contractor in accordance with the provisions and in conformity with the stipulations and requirements of ASTM Designation C144-70 or latest revision and shall have a fineness modulus between 1.6 to 2.5.

39.2.3 Water

The water used in the preparation of mortar shall be free from objectionable quantities of silt, organic matter, alkali salts and other impurities and it will be tested in accordance with BS-3148 and approved by the Engineer at the Contractor's cost.

39.2.4 Aggregate

Aggregates for mortar shall comply with the requirements of ASTM C144. Sand that has been in contact with seawater shall not be used unless it has been thoroughly washed to the satisfaction of the Engineer.

39.2.5 Additives

Additives where used, shall be proprietary products used in the proportions and manner recommended by the manufacturer. The additives shall in no way adversely affect the mortar strength or contain chemicals, which may be harmful to other building materials. To add gypsum to cement is strictly forbidden.

39.3 MORTAR AND GROUT

Materials for mortar, sand binding agent and water shall be mixed by volume for at least 3 minutes with the minimum amount of water to produce a correctly mixed mortar or grout of workable consistency in a mechanical batch mixer. For small jobs, hand mixing may be permitted, the ingredients being mixed with sufficient water to produce a correctly mixed workable mortar. Mortar used in masonry construction shall conform to ASTM C-270 standard.

Mortars shall be mixed in batches, which can be used within a period before the setting process commences. Once a mix begins drying off, it shall be rejected. No ingredients shall be added to it once the setting process has begun. Mortar shall not be retained for more than 30 minutes and shall be constantly worked over with hoe or shovel until used.

39.4 MORTAR BATCHING

Methods or equipment used for mixing mortar shall be such as will accurately determine and control the amount of each separate ingredient entering into the mortar and shall be subject to the approval of the Engineer. If a mixer is used it shall be of approved design and the mixing time after the ingredients are in the mixer, except for the full amount of water, shall not be less than two minutes.

Mortar shall be mixed only in sufficient quantities for immediate use and all mortar not used within 30 minutes after addition of water to the mix shall be wasted. Retampering of mortar shall not be allowed. Mixing pans and troughs shall be thoroughly cleaned and washed at the end of each day's work.

39.5 SCAFFOLDING

Contractor shall provide safe scaffolding of adequate strength for use of workmen at all levels and heights at his own expense. Scaffolding which is unsafe in the opinion of the Engineer shall not be used until it has strengthened and made safe for use of workmen. Cost of scaffolding etc., shall be included by the Contractor in the unit rate for masonry items.

Damage to masonry from scaffolding or from any other object shall be repaired by the Contractor at his own cost.

39.6 JOINTING

Jointing is the forming of joints as work proceeds. Joints shall be as follows:

- Exterior exposed joints shall be tightly formed to a weather joint with the point of the trowel.
- Interior exposed joints shall be tightly formed to a concave joints.

- Joints which are subsequently covered with plaster or other finish materials shall be struck flush.

39.7 BLOCKS

Cement, aggregates and water for concrete blocks shall conform to the requirements as specified in the section for plain and reinforced concrete or as approved by the Engineer.

39.7.1 Concrete Block Making

The solid and hollow blocks as and where used by planning, shall be machine moulded. The block making machines shall be of the standard approved by the Engineer. They shall be operated according to the instructions laid down by the manufactures.

The blocks shall be continuously water cured by sprinkling water for a minimum of 10 days and covered between sprinkling operations with 4 mils thick polyethylene sheeting. After the 10 days water curing period the blocks shall be air dried. Under no circumstances will blocks be used in the work until they are completely dry. During curing period no surfaces of the block will be allowed to dry.

Cured concrete blocks shall be stored off the ground, stacked on level platforms, which allow air circulation under stacked units. Units shall be covered and protected against wetting.

Care shall be exercised in the handling of all concrete blocks. No damaged blocks shall be used in the work.

The blocks cast on different dates shall be stacked separately and must be labeled showing the date on which they were cast.

39.7.2 Properties of Blocks

All blocks shall be of size and shape required to complete the work shown in the Drawings or as instructed by the Engineer.

The cement, sand and coarse aggregate shall be volume batched and their proportion may be adjusted so as to provide the concrete of the required strength when tested and shall be mixed in a concrete mixer.

All blocks shall conform to ASTM C 145 standard. The compressive strength based on gross area shall be minimum 8.30 MPa for an average of 3 blocks and minimum 7.0 MPa for lowest individual blocks with 28 days after casting Cement Concrete Solid Blocks.

The Contractor shall provide test certificates show in the average minimum crushing strength of the blocks prior to the commencement of the construction. Further test certificates shall be provided as required by the Engineer, to ensure that all batches of block strengths are to be determined in accordance with ASTM C- 140 Standard.

The test shall be carried out by a laboratory approved by the Engineer. Evidence shall be produced that the block manufacturer has an efficient method of quality control. The Engineer will require to test samples of blocks periodically and the Contractor shall make necessary arrangements accordingly. The method of sampling for all test shall be in accordance with ASTM C-140.

All properties or specifications of blocks, not explain in these Specifications or ASTM C 145 shall comply with the requirements of PS 419, as directed by the Engineer.

39.7.3 Erection

Block shall be laid true to line, level and laid in accurately spaced courses in stretcher bond with vertical joints of each course located at centre of units in alternate courses below. Vertical joints shall be buttered in the entire height of blocks. Each course shall be bonded. Courses of block shall be kept plumb throughout and corner reveals shall be true and in plumb.

Standard with of mortar joints for both horizontal and vertical joints shall be 7/16 inch (maximum). Mortar joints in wall shall have full mortar coverage on vertical and horizontal faces between the blocks. Mortar joints on wall including struck joints, shall be thoroughly compacted and pressed tight against the edges of the blocks with proper tools. Blocks terminating against soffits of beam or slab construction shall be wedged tight with wedges and the joints shall be packed solidly with mortar between the top of the block and the bottom of slab or beam. Control expansion joints shall e kept free from mortar or other debris.

Unless otherwise shown on the drawings or specified by the Engineer, the spaces around door frames and other material or built in items shall be solidly filled with mortar. Spaces around the door and window hold fasts shall be filled in with Class C concrete. Work required to be built in with masonry including door frame anchors, wall plugs, dovetail anchors and accessories shall be built in as the erection progresses.

The block work shall be carried out in a uniform manner and no portion shall be carried more than one metre above the adjoining one at any times. All masonry shall be kept strictly true and square and the whole properly bonded together and levelled round each floor.

Sleeves, Chases, holes, sinking and mortices for other trades shall be correctly located and formed to the sizes as required by the relevant trades. Chiselling of completed walls or the formation of holes shall only be carried out with the approval of the Engineer.

Walls of blocks indicated as being non-load bearing shall be constructed on insitu concrete floor slab unit after the floor formwork is struck and the concrete has obtained sufficient strength to support their weight. Toothing into load-bearing walls shall not be permitted.

All bolts, anchors, ties, pipe sleeves, flushing metal attachments lintels and the like required to be built into the work shall be correctly inserted and executed as the work proceeds.

Walls or partitions abutting concrete columns or walls shall be securely anchored and tied with metal anchors or ties at not more than 18 inches vertical centres. Wall ties cast in with concrete shall be bent down after the removal of form work and shall be securely jointed into the mortar beds of walling.

39.7.4 Curing and Repairs

All block masonry shall be water cured and shall be kept wet for at least seven days, by an approved method, which will keep all surfaces to be cured continuously wet. Water used for curing shall meet the requirements of specifications for water used in the manufacture of blocks.

39.7.5 Tolerances

All block work shall be erected plumb and true to line and level with the maximum variation in any storey height or any length of wall being one mm in one metre. The maximum tolerance in the length, height or width of any single masonry wall shall be $\pm 1/8$ inch.

If, after the completion of any block masonry work, the block is not in alignment or level, or does not, conform to the lines and grades shown on the Drawings or shows a defective surface, it shall be removed and replaced by the Contractor at his expense unless the Engineer grants permission, in writing, to patch or replace the defective area.

39.8 MEASUREMENT AND PAYMENT

39.8.1 Measurement

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 thereof shall be deemed to have been included in the quoted unit rate of the respective items of the Bill of Quantities.

39.8.2 Payment

Payment shall be made for the number of square feet or square metre (whichever is included in Bill of Quantities) at the contract unit price and shall constitute full compensation for furnishing all materials, equipment and labour including all incidentals necessary to complete the work in strict accordance with this section of specification.

SECTION - 40: UPVC PIPE

40.1 SCOPE OF WORK

The work covered by this Section of the specification consists of furnishing all plant, labour, equipment, appliances and materials and of performing all operations in connection with water supply lines and appurtenances in strict accordance with this section of the specifications and the applicable Drawings.

40.2 MATERIALS

Plasticised polyvinyl chloride (uPVC) and fittings if approved by the Engineer shall confirm to BS 3505 pipes shall be class B: Pipe and fittings shall not be stored directly exposed to sunlight handled or laid in conditions where ambient temperatures may cause distortion or damage. In extreme conditions, pipe and fittings may have to be stored under water.

PART - 9: ELECTRICAL WORKS

SECTION - 41: STREET LIGHTING SYSTEM

41.1 GENERAL

The work under this section consists of manufacturing, fabricating, supply, storage, installation, testing & commissioning of road lighting system read together with drawings & bill of quantity. The Contractor shall furnish all labour, materials, services, and skilled supervision necessary for the construction, erection, installation, and connection of all equipment. The extent of work specified herein and/or shown on the drawings represents the minimum requirements.

The Street lighting work generally is to be in accordance with the requirements of the Specification including luminaries, columns, related power distribution and control, protective earthing and related works including column foundations, cable trenches and all material with accessories and services for the complete Lighting system as specified herein.

The Street Lighting system components consist of:

- Street Light Pole
- LED Luminaries
- LV Power Cable
- Terminal box & Circuit Breakers
- Street light control panels (SLCP)
- Earthing

41.1.1 Standards

Luminaries generally are to comply with international standard i.e., BS/IEC and as per applicable. recommendations. Manufacturer is to verify compliance with these standards and the applicable local regulations and design standards.

41.1.2 Technical Requirements

Minor deviations from the Drawings may be considered for improvement in construction details, but no changes are to be made without the written approval of the client.

41.1.3 Ambient Conditions

Unless otherwise specified, equipment is to be designed and derated for continuous and trouble-free service at 55 °C ambient temperature and 100% relative humidity, with temperature reaching 70 °C in direct sunlight and with high content of ultraviolet rays. Equipment is to withstand full load operation whilst exposed to Sun.

41.1.4 Equipment

Submit complete data for approval including, but not limited to, the following:

- Detailed literature, in English, for each type of luminaire or fixture, lamp and control gear including manufacturer's name, catalogue number, rating, material specification, overall dimensions, operating characteristics and principles, and any modification to a standard product if applicable
- Detailed specification and drawings for each column type including shape, base/mounting flanges, bolts, nuts etc, cross-sections, design criteria and calculations, brackets, finishes, provisions for cabling, cut-out or circuit-breaker etc.
- Photometric data for lighting calculations including polar curves, coefficients of utilization, efficiency and depreciation factors. Street lighting shall be carried out with Pole mounted LED light fixture shown on the drawings and indicated in the BOQ.

41.1.5 Construction Drawings

Submit drawings for approval including, but not limited to, the following:

- Layout of equipment in exact positions with mounting and construction details, concrete foundation dimensions and reinforcement, routing and sections of duct- banks and trenches, backfill and packing material, earthing rods etc.
- Cabling and wiring diagrams, single line drawings, loads, phase distribution, protection and control, earthing.
- Calculations of illumination levels and glare, based on CJE methods.

41.1.6 Samples

The Contract shall Submit fully equipped sample of luminaire or other materials or components. The Contractor shall arrange two numbers of lighting Poles, prototype at site or at factory well before start the construction or fabrication of the Pole.

41.2 CONSTRUCTION FABRICATION OF STREET LIGHT POLES

The pole (vertical portion) along with base plate shall preferably be in one piece. The steel poles shall be galvanized by hot dip process both in and outside as per BS-729 (NFA 91121 and 91122 French), Octagonal steel poles complying with ASTM-A 501, BS 1840 I BS 4360 I BS 4848, NF EN ISO 1461 having height of 6m/8m/10m & 12m as specified in BOQ and drawings. Their cross-sectional shapes shall be tapered Octagonal and conform to dimensions given in the drawings. Hot Dip Galvanizing (TS 914 - ISO 9001) shall be carried out after removing grease, burs and slag etc. so that zinc coating is adherent,

dense, smooth, continuous and uniform. Minimum Zinc Coating 86 microns shall be required. The steel used in the manufacture of poles shall be made by open hearth or electric furnace process.

The contractor shall ensure before placing of order that the firm has adequate facility for hot dip galvanizing process as per standard practice.

The steel for poles shall have the following requirements:

Tensile Strength

Minimum	39.9 kg/mm ²
Maximum	56.3 kg/mm ²

Yield Point

Minimum	24.7 kg/mm ²
Elongation for a 200 mm sample	20% min

The straight portion of the pole shall be truly vertical and no deviation more than 100 mm in the entire length shall be accepted.

Other tolerances shall be as follows:

Outside diameter	+1%
Wall thickness	+10%
Overall Length of pole	+0.5%
Weight	-0.3% +Not Limited

The pole and the bracket shall be so designed that when subjected to wind at a velocity of 160 km/hour on the full projected area of pole, bracket and the luminaire; a factor of safety of 3 on minimum tensile strength of the material shall be obtained. In addition, the temporary horizontal deflections at the luminaire position shall not exceed 1/40 of the length of the pole above ground at aforementioned wind velocity.

The Lighting Pole, single or double arm type shall be fabricated from 4 mm thick MS sheet. Poles shall be made in such a way that only one (1) sheet of steel plate is used to form a round conical/octagonal/tubular pole. Welding shall be carried out along one edge of the poles only. Poles seam welding shall comply with the latest edition of EN 1011-2 by automatic continuous welding process.

Poles shall have self-locking inspection door open-able with special key only. Pole inner compartment or pole inside dia. in front of inspection door shall be suitable to hold cable connection box.

The edges of the door opening on the pole shall be reinforced with a 10 mm thick M.S square bar to reinstate the strength of this location. The opening cover shall consist of waterproof hinged door with gasket. The door shall be with heavy non-rusting lock.

The poles base compartment, designed to accommodate a loop-in services cut-out for 4 cores PVC/SWA/PVC cable, the cable sizes given in drawing. An 8 mm stainless steel stud complete width nut and washers shall be provided in the base compartment of the pole for earthing purpose.

The material used for strapping the poles together during the delivery shall be of non-rust type. This is to prevent rust from appearing at the straps due to weather if stored for a long period.

Adequate arrangements shall be made to restrict bracket to rotate around the axis of pole at aforementioned wind velocity.

The J-bolt size shall be of 25 mm diameter and of galvanized Carbon steel. Each individual J-bolt shall be complete with Galvanized washers and nuts.

41.3 INSPECTION AND TESTING STREET LIGHT POLES

41.3.1 General

The poles shall be tested and results recorded for each test by the manufacturer in the presence of an authorized representative of the owner or Engineer.

To verify conformance with the requirements of this specification and quality assurance of the Octagonal Poles Engineer's designated representative will conduct acceptance inspection and witness testing at the manufacturer's factory.

41.3.2 Inspection / routine Test requirements

The material, weight and dimensions of poles as specified shall be certified by the manufacturer. The Poles shall be inspected and in case being found below the limits of tolerance as aforementioned, shall be rejected.

Visual inspection shall include but not limited to: dimensional verification, checks for satisfactory workmanship, material quality, freedom from surface defects, even distribution and thickness of Galvanizing coating, and for compliance with the purchase order requirement, as applicable.

41.3.3 Loading Test

The poles shall be cantilevered horizontally and rigidly supported at base plate and loads applied at right angle to axis of the pole at some distance from top. The test items shall be as follows:

- Deflection test
- Permanent set test and Breaking Load Test

Sample comprising four poles shall be selected random out of each lot 50 and subjected to deflection test. One pole per 250 shall be tested for permanent set test and breaking load test. When the poles in Tender are limited in number, the manufacturer may avoid deflection, permanents set

and breaking load test and supply results of tests already done for prototype testing on such poles or supply calculation-based results.

41.3.4 Galvanizing

Weight, uniformity of coating and other requirements shall be strictly inspected in accordance with BS-729 or other relevant international standards.

41.3.5 Terminal Box

Each pole shall be provided with a waterproof and dust tight loop-in-service Terminal box accommodate in the Pole shaft.

The Terminal box shall comprise one 2 A MCB single arm poles and two 2 A MCBs for double arm poles (all MCBs shall be capable of operating at 55°C), a solid neutral link and earthing terminal. It shall incorporate arrangements for looping "IN" and "OUT" for 4 core up to 70 mmsq PVC/SWNPVC cable. The earth terminals, nuts and washers shall be adequately sized to take the earth continuity conductor with tight connections.

Dimensional drawing and details of the Terminal box shall be submitted for approval of the Engineer.

41.4 INSTALLATION OF STREET LIGHTING POLES

41.4.1 Erection of Street Light Pole

The fixing of poles shall be carried out in accordance as per drawing and Specification or as directed by the Engineer.

The poles shall be erected in a true vertical position. The contractor shall be responsible until completion of the maintenance period for correcting the alignment of any pole/bracket from its original position except where it is due to vehicle impact.

Where lighting poles are to be installed in the vicinity of overhead power lines, the Contractor shall inform the Engineer and act as directed by him. Earth backfill around pole foundation, shall be done in 150 mm thick layers and shall be well rammed and compacted to provide full lateral support.

Selection of Street Lighting Poles of any manufacturer out of approved manufacturer's list will be decided after the installation / Testing of samples at site in the presence of client, consultant & contractor.

Final Selection of the Street Lighting Poles will be done after mutual agreement of Client & Consultant.

No escalation (if any) will be paid for Poles selected by mutual consent of client & consultant.

41.4.2 Foundation of Lights Pole:

The installation of poles shall be carried out on the concrete foundations, as per approved drawings. Foundations for lighting columns, poles, posts and pedestal shall be as per drawing having concrete cube strength specified at 28 days of 3750 psi nominal mix concrete, with Sulphate resisting cement used where required by the Engineer. Forms of foundations shall be true to line and grade, and the exposed portions shall present a neat appearance. Conduit ends and anchored bolts shall be held in place with a template till concrete sets, plumbing of the column/pole shall be accomplished with the levelling nuts before placing of mortar; shims, or similar devices, will not be allowed. The space between the base plate and foundation block shall be grouted with foam concrete as detailed so as the cable is not damaged. Pre-cast foundation shall be allowed and the foundation shall be cured for at least 14 days dried for 3 days and then the bituminous coating shall be done to the outer face of the concrete block which shall be buried in soil.

The installation work shall be carried out in accordance with the specifications as well as to the approval by the Engineer. The soil bearing capacity at the site shall be ascertained so that the foundations can be correctly designed.

41.4.3 Pole Internal wiring

An adequate length of PVC/PVC sheath cable, 3 core 2.5 Sq.mm rated at 450 I 750 Volts shall be provided for the connection between Terminal Box Circuit breaker and the Light Fixture. The cables shall be properly supported to prevent undue strain on the cable terminations. The cable color identification shall comply with the latest Standards

- The cables used shall be manufactured to the latest edition of IEC 60502-1.
- Internal wiring of luminaries shall be carried out with heat-resistant cables, and additional protective sleeves apply at critical points.

41.4.4 Cable Terminal Box

The cable terminal box shall be made of impact resistant, flame retardant thermoplastic material. All metal parts either stainless steel or galvanized copper alloy.

The cable Terminal boxes shall be IP 65 rating protection class suitable for 400 Volts minimum.

The Terminal boxes shall fit in with ease into the lighting column I pole. The connection boxes shall be in accordance to IEC and DIN-VDE standards.

- IEC-60439 (LV Switchgear)
- VDE 0660 - 505 (Switchgear and Control Gear)
- DIN 43628 (Fuse I Breaker Boxes for Cable Protection)

The cable Terminal box shall be in accordance to the wattage of the lamp.
The cable connection box shall constitute in the following:

1. Earth cable break-out and connection.
2. Miniature Circuit Breaker (MCB) DIN rails mounted. 1 or 3 Nos. where applicable.
3. Miniature Circuit Breaker rating shall be in accordance to the wattage of the lamp
4. Lamp cable connection area:

The cable connection box shall be suitable for the number of incoming I outgoing cable sizes as per design.

Pole shall have one number earth lug at inside the Termination box. The pole shall have overhang arms to hold light fittings I fixtures weight of 20 kg (approx.). The base plate to the main shaft is electrically welded at factory. Any damage to galvanization during transport shall be made good. No welding to any part of the pole shall be done after it is hot-dipped galvanized in and out with base plate pre-welded to the main shaft and inspection door.

For all types an earthing connection point may be provided inside the shaft near the door opening without reducing the space of electrical gear.

Data to be Submitted

Before manufacturing, the contractor shall provide the following data:

- Manufactures
- Country of origin
- Type with manufacturer's catalogue and descriptive leaflet
- Details of construction with detailed specifications of material used for Column and holding down bolts
- Details and its welding procedure and material used in the welding.
- Calculation showing details of stresses under maximum wind loading and gusting
- Calculations and sizes for necessary concrete support bases
- Design calculation sheets for the poles from manufacture shall also be submitted by the Contractor to show that poles/foundations are safe for all specified stresses
- Shop drawings of the offered Pole.

41.5 PACKING AND SHIPMENT LIGHTING POLE

Lighting Poles shall be handled I transported and erected in such a way so as to avoid any damage. Any damage to pole or galvanizing shall be made good to the satisfaction of the Engineer. The lighting Poles shall be stored

clear of soil, ground water or other rust producing materials.

In addition to the packing and shipping requirements, the following shall be fulfilled:

- A) The Pole shall be stacked with spacers and blocks in order to avoid damages of zinc coating during the loading and transportation.
- B) All Octagonal steel poles in conformance with the requirements of this specification shall be supplied pre-assembled, i.e., top cap and bearing plates are pre-installed on the pole shaft. Supplying any loose part/component is not acceptable.
- C) Poles shall be delivered in bundles of 6 poles with the arrangement of 2 layers, with 3 poles per layer, and strapped at four (4) locations of equal distances with the use of high tensile, low-elongation steel straps size 31 mm x 0.8 mm (min.) and necessary wood separators, padding or cushion material underneath the steel straps.
- D) Wooden separators shall be provided between the horizontal and vertical layers of poles to avoid scratches and to facilitate slinging.
- E) Bundled poles shall be so arranged such that the earthing hardware are not disturbed during normal handling.
- F) Reasonable care shall be exercised in the handling and shipment of steel poles. Any expense incurred due to the careless handling and shipment of steel poles shall be considered as a legitimate back charge against the supplier.
- G) Extra care shall be taken during the transportation and storage to prevent the poles from damage.

41.6 STREET LIGHT FIXTURES

41.6.1 General:

The work under this section consists of manufacturing, fabricating, supplying, installing, testing and commissioning of all material with accessories and services for the complete LED fixtures as specified herein.

The contractor shall submit the technical details of the luminaries and other equipment and having obtained conditional approval thereof; submit in duplicate, full detail of the calculated results for the level and uniformity of luminance and illumination on all road surface.

The light fixture shall be posted on single or double arm pole as shown in drawings. The luminaire shall be fixed on to the Pole and are interconnected through the cables. The street light operates in the stand-alone mode.

41.6.2 Ambient Conditions:

Unless otherwise specified, equipment is to be designed and derated for continuous and trouble-free service at 50 °c ambient temperature and 100% relative humidity, with temperature reaching 70 °c in direct sunlight and with high content of ultra-violet rays. Equipment is to withstand full load operation whilst exposed to sun.

41.7 CONSTRUCTION OF STREET LIGHTING FIXTURE

41.7.1 Housing

The fixture shall have a full die cast aluminium housing providing adequate rigidity, strength and heat dissipation.

The housing shall have integrated driver and LED lamp compartments for better heat dissipation and convenience in maintenance at the site, and shall feature highly reflective components and films to increase light output.

The optical LED compartment shall have thermally hardened glass cover and high-quality silicon gaskets. The glass shall be extra-white for maximum light transmission. The glass cover shall be tightly secured with housing. The complete fixture shall be rated for ingress protection class IP66. Both the driver and LED lamp compartments shall be designed to be easily accessible for maintenance

41.7.2 Optics

The fixtures shall have flexible optical systems for various wattage range. The fixture shall use high efficiency LED and optics system.

The Light output Ratio (LOR) shall not be less than 85%.

The fixture shall offer a composite system efficiency of more than 130 lumen / watt.

The lens system design and high efficiency LED shall facilitate maximum spacing between the road lighting poles and coverage of wider roads.

The multilayer optics design shall ensure adequate luminance uniformity in the unlikely event of individual LED failure.

The fixture shall offer choice of narrow, medium and wide beam light distribution.

The optics lens system shall have choice of narrow, medium and wide beam light reflectivity for maximum light output.

41.7.3 LED Driver/Electronic Control Gear for LED Modules

The LED driver shall be designed to operate large array of high-powered LEDs through current controlled output. The driver shall be suitable for 230V, + 10% - 15%, 50Hz, single phase mains AC supply. The LED driver shall have an efficiency of at least 85%.

The LED driver shall be manufactured Harvard, TCL, Philips, Lumotech, Bossich Schwabe, Lightech.

41.7.4 LED

The LED Chip shall be Philips, Creeer make,

The LEDs shall:

- Be designed for lumen maintenance of L70 or 70% at the end of useful life at ambient temperature of 50 Degree Centigrade.
- Have a useful life of 50,000 burning hours.
- Have a minimum color rendering index (CRI) of $80 \pm 10\%$ and a color temperature upto 6500K as per Client Approval.
- Selection of LED Light of any brand out of approved manufacturer's list will be decided after the installation / Testing of samples at site in the presence of client, consultant & contractor.
- Final Selection of the LED Light will be done after mutual consent of Client & Consultant.
- No escalation (if any) will be paid for LED light fixtures selected by mutual consent of client & consultant.

41.7.5 Surge Protection

The lighting fixture shall have surge protection to protect the electronic driver and LED system. Minimum surge protection rating shall be 10 KV.

SPD should comply to IEC 61347-2-7 and should be listed in Luminaries IEC 60598-2-3

41.7.6 IP Protection I Impact Resistance

The complete fixture including lamp and gear compartments shall have ingress protection class IP66 for Road Lights and IP65 for Flood Lights long reliable performance and minimal maintenance requirement and an impact Resistance of IK08 or above. No chemical glue shall be used as that may cause breakdown of water-proof and dust-proof seal.

41.7.7 Thermal Management

Managing thermal properties in LED fixtures is most critical to ensure optimum performance of LEDs and reliability of the system. The housing under the circuit board shall be specially designed to ensure perfect contact between the board and the 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 dielectric layer. The metal core PCB shall be mounted on the housing using a highly efficient thermal interface material. Use of silicon glue is not acceptable.

The housing over the driver chamber shall have additional ribs to ensure direct contact with the drivers. The housing shall have adequate surface area

to ensure fast heat dissipation.

41.7.8 Photometric

Fixtures shall have illumination Engineering society (IES) Type II or III distribution pattern, with short or medium longitudinal distribution.

LM-80 LED and photometric test reports and IES files from a third-party testing laboratory shall be required.

41.7.9 Future Compatibility

The 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 tool-less gear-tray. Lamp compartment shall have easy access for opening the glass cover.

41.8 INSTALLATION OF LIGHT FIXTURE

The mounting of the fixture shall be in axial orientation through suitable sized sidearm. The means for attaching the luminaries or external part to its support shall be appropriate to the weight of luminaire or external part. The connection shall be designed to withstand wind speeds of 160 Km/hr on the project surface of the assembly without undue deflection.

All Street lights to be energized through street light control panels (SLCP), Approval of the Consultant shall be obtained before ordering and manufacturing the equipment.

All lighting shall be controlled automatically with the facility of manual control as well as specified and indicated in the drawings. Automatic controlled shall be installed comprising time switch, time relay, air breaker contactor etc.

41.9 WARRANTIES

The complete fixture including all accessories shall have at least three (3) year warranty (after one year of defect liability period) against defects and failures.

41.10 APPLICABLE STANDARDS AND CODES

The fixtures shall conform to the following latest standards and codes

- IEC 60598-1
- IEC 60598-2-2
- IEC 60598-2-3 (Road & Tunnel Lights)
- IEC 6247-1 (For the complete fixtures being offered as well as for the LED Chips)

- LM-79 (for the Luminaries being offered (Model/Wattage specific)
- LM-80 (for LED chips being used)
- LM-82-12 (Approved method of measuring LPW @ 50° C (Model/Wattage specific)
- UL-1598 (for thermal management test, Model/Wattage specific)
- EN 55015: 2006 and 2007 – Limits and method of measuring radio disturbance characteristics of electrical lighting)
- EN 61547: 1995 / +A1: 2000 – Equipment for general lighting purpose EMC immunity requirements
- EN 61000-3-2: 2006 – Limitation of harmonic current emission
- EN 61000-3-3: 2006 – Limitation of voltage fluctuation and flicker
- EN 62493 Assessment of lighting equipment related to human exposure to electromagnetic field (Environmental friendly)

The LED driver shall confirm to following latest standards and codes:

- EN 61347-1: General and Safety requirements
- EN 61347-2-13: particular requirements for DC or AC supplied electronic control gear for LED modules
- EN 61384: DC or AC supplied electronic control gear for LED modules performance requirements
- EN 61548: 1995 / +A1: 2000 – Equipment for general lighting purpose EMC immunity requirements
- EN 62384: AC or DC supplied electronic control gear for LED modules performance requirements
- Technical and descriptive data and drawings.

41.11 TECHNICAL AND DESCRIPTIVE DATA AND DRAWINGS

Technical and descriptive data and drawing to be submitted shall include but not limited to the following:

- Technical data of fixtures and driver.
- IES Photometric file (absolute photometric data)
- LM-79 test report for each of the fixture type/ wattage shall be required.
- LM-80 test report of LED used
- LM-82-12 approved method of measuring LPW @ 50°C (test report of the fixture type / wattage shall be required.
- Thermal management test report (UL 1598) of the fixture type/wattage shall be required.

- EN 62493 test report
- IK rating test report
- Lumen depreciation test report at 1000, 2000, 3000 and 6000 burning hrs.
- 3rd party IEC 60598 test reports
- Vibration test reports
- EMC test reports
- Salt spray test report
- Photo- biological safety test report
- Customer's testimonials
- Factory ISO certificate
- Report of other type tests stipulated in the respective standards/codes.
- Country of origin, Manufacturing works I factory details, premises & QA & QC procedure, in house testing procedure, routine testing procedures and test reports, testing equipment details are also being provided in order to ensure proper traceability and quality assurance on each piece of the product being delivered.

41.12 INTERNATIONAL INDEPENDENT LABORATORIES

For the specified requirements of type tests and type test reports by an independent authority/independent laboratory, the following laboratories shall be considered as independent laboratories:

- KEMA Labs, Holland.
- CESI Labs Italy
- CRIEPI Labs, Japan.
- Any laboratory accredited by EA (European Co-Operation for Accreditation) or a member thereof.
- Any member of thereof
- Any laboratory accredited by IAF (International Accreditation Forum) or a member thereof.
- Any laboratory accredited by STL (short-circuit Testing liaison) or a member thereof.

41.13 PRE-SHIPMENT INSPECTION (WITNESSING OF FACTORY ACCEPTANCE TESTS)

In order to ensure the genuineness of the lighting fixtures, Factory Acceptance Tests (FAT) as stipulated in the relevant standards shall be witnessed by the personnel of the Employer and the Consultants. All costs in

connection with witnessing of the factory tests by the Employer and the Engineer shall be borne by the contractor. These shall include the cost of air travel from Pakistan to place of inspection/testing and back, hotel accommodation/boarding/lodging (as per actual), inland transportation and daily allowance for inspection/testing to be conducted outside Pakistan.

41.14 STREET LIGHT LV CABLES

The street light cables shall be 4 core 600/1000 Volt grade PVC I PVC cable. The size and Type of cable shall be as per drawing,

The cable shall be as per BS I IEC latest Specifications. The cable shall be suitable for direct burial, or installation in ducts as shown on drawing. The cable shall be laid in the already excavated trenches as per drawing provided by the Consultant. The instructions of the manufacturers shall be followed for laying the cables in addition to general instructions of laying the underground cables. This shall carry approval of the Consultant I Engineer.

The LV cable specification shall be same as already specified in Section - "LV Power Cables".

41.15 STREET LIGHT CONTROL PANEL

41.15.1 Materials

The street light control panel shall comprise of the control device and A.C. contactor for correct and reliable opening and closing of the contacts. The control device shall be photoelectric. The equipment shall be installed within a weather proof, dust proof and moisture proof cabinet. It shall have a small transparent window for photoelectric cell. The MCB shall control a group of lights and MCCB shall be rated to their total current. It shall be lockable.

The SLCP enclosure shall be Vermin proof, for this purpose two metal sheets one fixed and other removable and sliding, with necessary provision of adjustable slots for cable entry shall be provided to seal off the bottom of the SLCP.

41.16 MOULDED CASE CIRCUIT BREAKER

A Triple Pole 500 Volts, 50 Hz. MCCB shall be used as incoming breaker for SLCP.

41.17 MINIATURE CIRCUIT BREAKER

Miniature Circuit Breakers shall be provided on each outgoing circuit for short circuit protection.

41.18 TIMER SWITCH

Synchronous motor operated time switches shall be installed having 12/24 hours auxiliary sparing reserve operating on 220/250-volt, 50 Hz. with plug in

type time switch and base incorporating one normally open and one normally closed contact of minimum 5-Amp's size. An adjustable band-set or solar dial shall be provided in the timing switch for setting of switching time.

41.19 PHOTOELECTRIC CELL

The photoelectric cell and actuating relay shall have the following mentioned below; The photoelectric cell shall have the following ratings: -

Operating Voltage range	210 to 250-volt AC
Load Current Capacity	10 Amps.
Light Levels.	To turn ON 50 Lux
To turn OFF	200 Lux

41.20 RELAY (MAGNETIC CONTACTOR)

It shall be triple pole single throw and of electromagnetic type. Pole magnet shall be dimensionally stable. Performance shall be chatter free. Contacts shall be of long life at rated load. Some arrangements shall be provided with the armature to counter-act the effect of high inrush current.

The A.C. contactor for closing and opening of electrical street lighting circuits shall have the following features:

- A) Maximum Ambient Temperature 50 °C and relevant humidity up to 100%.
- B) The rated operational voltage of the contactor shall be 415 volts A.C.
- C) The rated control supply voltage for operating the contactor shall be 230 volts A.C. single phase.
- D) The Contactor shall close satisfactorily with a control voltage between 85% and 70% of the rated voltage. The dropout voltage shall not be higher than 75% nor (with worn contacts) lower than 10% of the rated control supply voltage.
- E) The rated thermal current which the contactor shall carry without exceeding the temperature limits specified in the relevant clause of the provided specifications shall be 60, 50 or 40 Amps.
- F) The rated operational current of the contactor shall be 60, 50 or 40 Amps.
- G) The rated frequency shall be 50 Hz.
- H) The Contactor shall be suitable for uninterrupted duty, that is to remain closed without interruption for periods of more than 8 hours.

The material and constructional features of the street lighting control devices and AC Contactor shall be as per latest Standard I Specification.

The control panel mechanical and electrical design shall be as per drawings provided herein and approved of the Consultant I Engineer.

41.21 INSTALLATION OF THE LIGHTING CONTROL PANEL

Concrete Pad shall be constructed for the installation of Lighting Control Panel. The size of concrete pad given in drawing is tentative. The Contractor shall submit the foundation shop drawing after approval of SLCP shop drawing. The installation shall also carry approval by the Engineer.

Schedule of Technical Data to be filled in for every Type / Model & Wattage of LED Road Lighting Fixture and Sealed by the Manufacturer (Mandatory)

Description	Data/Parameters/Values to be filled in by the Bidder / Manufacturer
Make	
Model	
Country of Origin	
Main applications	
Wattage	
Max. power consumption	
IES Photometric File (Yes/No)	
• Materials and finishing	
Housing	
Gaskets type & characteristics	
Optics	
Glass Type	
Dimensions (LxBxH)	
Weight	
Windage area	
Classification code	
IP Rating for Fixture	
IP Rating for Gear compartment	
IK Classification	
Class	
• Color & Material	
Frame	
Hinge	
Clip	
Canopy	
Installation	
maintenance	
• LED Chip Make, Model & Country of Origin	

Description	Data/Parameters/Values to be filled in by the Bidder / Manufacturer
CREE (Yes/No)	
NICHIA (Yes/No)	
OSRAM (Yes/No)	
PHILIPS LUMILED (Yes/No)	
LED Color consistency (SDCM) Limits in %	
Optic	
Narrow Beam	
Medium Beam	
Wide Beam	
LED Driver/Electronic Control Gear Make, Model & Country of Origin	
Harvard (Yes/No)	
TCI (Yes/No)	
Philips (Yes/No)	
Lumotech (Yes/No)	
Vossloh schwabe (Yes/No)	
Lightech (Yes/No)	
Optical cover	
Line Voltage	
Main's voltage performance (AC)	
Min. Mains voltage operational	
Power Factor	
- At Normal Power	
- At Dim levels	
Surge protection	
- Differential Mode	
- Common Mode	
Earth leakage current (Max.)	
Light Source	
LED driving currents	
System efficiency	
System lumen output	
Optics LOR (Light Output Ratio)	
CRI (Colour Rendering Index)	
Color temperature as per ANSI C78.377A	
TA	
Lifetime: Ta = 35°C @ LM70	
Connector type & make	

Description	Data/Parameters/Values to be filled in by the Bidder / Manufacturer
Cable gland types & make	
Wire isolation (all wires are to be isolated singly)	
Energy Saving Options	
Dimming options	
Programmable	
- No of Dimming levels	
- Wattage @ different Dimming Levels	
Warranty	
- Fixture	
- Driver	
- LED	
Future Upgrades and compatibility	
Certifications and Type Test reports	
FACTORY ISO CERTIFICATION	
ISO 9000	
Type Test Enclosed (Yes/No)	
ISO 14000	
Type Test Enclosed (Yes/No)	
ISO 18000	
Type Test Enclosed (Yes/No)	
Fixture	
IEC 60588-1-2-3	
Type Test Enclosed (Yes/No)	
Type Testing Agency	
Photo Biological Safety tests – IEC 62471	
Type Testing Agency	
Type Test Enclosed (Yes/No)	
General & Safety Requirements – EN 61347-1	
Type Test Enclosed (Yes/No)	
Type Testing Agency	
LED Modules – Requirements of AC or DC supplied electronic control gear – EN 61347-2-13	
Type Testing Agency	
Type Test Enclosed (Yes/No)	
LED Modules performance requirements – AC or DC supplied electronic control gear – EN 62384	

Description	Data/Parameters/Values to be filled in by the Bidder / Manufacturer
Type Testing Agency	
Type Test Enclosed (Yes/No)	
Limits and methods of radio disturbance characteristics of electrical lighting EN 55015: 2006 and 2007	
Type Testing Agency	
Equipment for general lighting purpose EMC immunity requirements EN 61547: 1995 / +A1: 2000	
Type Testing Agency	
Limitation of harmonic current emission EN 61000-3-2: 2006 – Limitation of harmonic current emission	
Type Testing Agency	
Limitation of voltage fluctuation and flicker EN 61000-3-3: 2008	
Type Testing Agency	
LM-79 Test report for each of the fixture type / wattage being afford.	
Type Testing Agency	
Type Test Enclosed (Yes/No)	
LM-80 Test Report of LED used	
Type Testing Agency	
Type Test Enclosed (Yes/No)	
LM-82-12- Approved method of measuring LPW @ 50°C (Test Report) of the fixture type / wattage being offered	
Type testing Agency	
Type Test Enclosed (Yes/No)	
Thermal Management Test Report (UL 1598) of the fixture type/wattage being offered	
Type Testing Agency	
Type Test Enclosed (Yes/No)	
EN 62493 – Test report	
Type Testing Agency	
Type Test Enclosed (Yes/No)	
IK rating Test Report	
Type Testing Agency	
Type Test Enclosed (Yes/No)	
Lumen Depreciation Test Report at 1000, 2000, 3000, and 6000 Burning Hrs	

Description	Data/Parameters/Values to be filled in by the Bidder / Manufacturer
Type Testing Agency	
Type Test Enclosed (Yes/No)	
Vibration Test Report	
Type Testing Agency	
Type Test Enclosed (Yes/No)	
EMC Test Report	
Type Testing Agency	
Type Test Enclosed (Yes/No)	
Salt Spray Test Report	
Type Testing Agency	
Type Test Enclosed (Yes/No)	

Sr No	Feature Description	Req Value
1	LED Categories	As per Specifications
2	LED Fixture efficiency	> 120 Lm/W
3	Power Factor	>0.95
4	Impact Resistance	IK08 or above
5	IP Rating (Ingress Protection)	IP 67
6	CRI (Color Rendering Index)	>80±10%
7	Useful Life at 50 Degree Centigrade	>100,000 burning hours
8	Min Efficiency of Chip	>160 Lm/W
9	LED Chips	Cree, Nichia, Osram, Lumiled
10	Light Adjustment Angle	± 5 - ±15 degree
11	Certification	EA, ILAC, IAF, STL
12	Annual Depreciation of LED Lights	Must not be more than 3% per Annum
13	CCT (K)	Upto 6500K
14	Light Fixture	Di- Cast Aluminum Supported by reports IESNA LM-79-08
15	Charger Controller	Capable with Intelligent Movement Sensors
16	Li or Equivalent Battery	Operating Temp >60 Degree
17	Solar Cylinder Panels (A Category) Mono Perc	Life > 25 Yrs, Max Annual Depreciation of 3%
18	Soft Copy of IES files of each wattage of LED Street Lights must be submitted with Technical Bid	
19	Warranty - 5 Years	

SECTION - 42: EARTHING SYSTEM

42.1 SCOPE OF WORK

The work under this section consists of supply, installing, testing and commissioning of all material and services of the complete earthing system as specified herein, as 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 route, location and position of the electrical lines and equipment.

The Earthing system shall also comply with the General Specifications for Electrical Works and with other relevant provisions of the Tender Documents.

42.2 GENERAL

The work will include supply, installation, testing and commissioning of Earthing System and conforming to the technical specification including the termination of the earth conductor from each earth pit to the main earth bus inside the building.

The earthing system consists of Earth Electrodes, Earthing leads, Earth connecting points, Earth testing point, continuity conductors and all accessories necessary for the satisfactory operation of the associated electrical system.

42.3 APPLICABLE STANDARDS / CODES

The latest editions of following standards/ codes shall be applicable for the materials in scope of this section:

8895	Earthing clamps
CP1013	Earthing
BS2874	Nuts. Bolts, washers, screws and rivets for use on copper
BS1433	Hard drawn bare copper conductor for earthing
BS6346	PVC insulated cables.
IEEE	Std 80

42.4 MATERIALS

The Earthing system shall consist of Earth electrodes, Earthing leads, Earth connecting point, Earth continuity conductor and all accessories necessary for the satisfactory operation of the associated electrical system. All Earthing material should be made of copper.

42.5 GROUNDING ELECTRODES

The grounding electrode shall be of Copper Rod 20 mm dia 3 m long. The contractor shall carry out resistivity test over the site area and submit the result to the Engineer. The number of grounding electrodes and the method of installation shall be approved by the Engineer depending on test results.

42.5.1 Earth Connecting Points

The earthing leads from the rod shall terminate at the earth connecting points which shall be of tinned copper bar, rectangular in shape, having dimensional 250mm x 50mm x 8mm, installed on the wall of the inspection chamber at the ground level. Further connections to respective locations shall be made from this bar by earth conductors of various sizes as shown on the drawings. All below Grade Earthing connection should be Cad Weld

42.5.2 Inspection Chamber

At the ground level an inspection chamber shall be provided. The inspection chamber sizes and detail shall be as per drawing. The cover shall have "EARTH BELOW" inscribed on its top. The Contractor shall provide and install the cover flush with the ground level.

42.5.3 Earth Lead/ Earth Continuity Conductor

The earthing lead shall connect the earth electrode to earth connecting point or equipment. It shall be single core PVC or hard drawn bare Copper Conductor as per drawing.

42.6 INSTALLATION OF EARTH ELECTRODE (COPPER ROD)

The earthing system by copper rod shall consist of 20mm dia and 4-meter-long copper rods. These shall be of 99.9% purity copper. These shall have screw able head to accommodate other rods in series with the help of dowel as is shown in the drawings. The driven head shall consist of a hardened tip. These rods shall be connected to the earthing lead whose other end shall be connected to the earth connecting points to be provided in the inspection chamber. From the earth connecting points earth connection shall be made to individual point as marked in drawing.

Installation of Earth Electrode where the condition not suitable for achieving Earthing ohms Where the rock lie just below the surface or water table are very deep then earth electrode shall be installed through drilling or digging method. Due to certain ground conditions make it difficult to obtain a reliable earth resistance, whilst particular installations may require a very low resistance, in such cases, Marconite concrete shall be used as backfill for a conventional earth rod achieve a lower earth electrode resistance. The method already is shown in the miscellaneous drawing.

42.7 EQUIPMENT GROUNDING

42.7.1 on-current carrying metal parts:

Bond and ground non-current carrying metal parts of electrical apparatus and equipment provided under work of any section of specifications.

42.7.2 Grounding of Fence:

All metallic fences shall be grounded by driving earth rods at a distance of 50 meter.

42.8 EARTH RESISTANCE & INSPECTION TEST

Earth resistance test will be made by the Contractor on the complete 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 measure's Electrical resistance of ECC together with the resistance of electrode to any other positioning the complete installation will not exceed one Ohm.

The earth resistance test shall be performed as per Standard requirements. Where more than one earth electrode is installed the earth resistance test of each electrode will be measured by means of resistance bridge instrument. Complete system shall be tested for continuity and earth resistance. The combined earth resistance at any point in the system shall not exceed 5 Ohms maximum.

Earth resistance test shall be made by the Contractor in the presence of the Engineer. The test result shall conform to BS 7430 (formerly CP 1013), IEEE 80 and BS 6651 (Formerly CP 326). To obtain the desired result more earth rods shall be provided.