KARACHI NEIGHBORHOOD IMPROVEMENT PROJECT
(KNIP)

REHABILITATION AND UPGRADATION OF BOAT BASIN TO SCHON CHOWRANGI WITH PEDESTRIAN TRAIL AND GIZRI SPORTS GROUND

BIDDING DOCUMENT
VOL-II
TECHNICAL SPECIFICATIONS FOR ROAD WORKS
AUGUST-2021

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EARTHWORK

ITEM 100 GENERAL

100.1 DESCRIPTION

Earthwork will consist of all necessary work for the excavation and placing in embankment or backfill or disposal by dumping of earth, 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 subgrade material, the formation of laybyes, the widening of cuts and the flattening of cut slopes whether to obtain material for embankments of 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.

100.2 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 earth and rock, its quantity, locations and suitability to meet the specified requirements, 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.

100.3 EXPLOSIVES

Where explosives are used the Contractor shall provide suitable buildings or warehouses in approved positions for the storage or 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 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.

100.4 REMOVAL OF EXISTING OBSTRUCTIONS

The pay items under Items 101, 103, 105, 106, 107 and 108 shall include the cost of removal of all material regardless of his nature, encountered within the limits of the approved cross-section, including the removal and disposal, as required by the Engineer, of existing brick, stone, concrete or masonry, rock boulders or fragments, old pavements, culverts, bridges or parts thereof, retaining walls or any other material encountered during the excavation, unless a separate item exists for such features.

100.5 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 provided necessary facilities of 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 effect 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 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 the necessary to keep the accumulated water at a level required for the safety of the structures as directed by the Engineer.

100.6 DITCHES

The Contractor shall construct side ditches, interception ditches, any 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, subgrade, 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, subgrade or pavement. He shall clean and trim all such drainage ditches from time to time, so that there may be 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 completion of the other construction work and shall be 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 item 105 or 106 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 be proceed without written approval of the marked cross-sections by the Engineer.

100.7 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 as provided in Item 501.

100.8 LANDSLIDES, BENCHES, FLATTENING OF SLOPES

The Engineer may order the removal of material resulting from landslides, the construction of benches in above the cut slopes 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 item 106 or 108 as the case may be.

100.9 SURVEY AND LEVELING PRIOR TO COMMENCE OF EARTHWORK

The Contractor shall be responsible for the setting out of the work in accordance with Clause 17 of the General Conditions of Contract. Notwithstanding that project drawings have been issued to the Contractor,

the Contractor 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 provide that shall be in the form and manner as instructed in writing by the Engineer.

100.10 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 Clause 109.9 above. However if the levels so taken differ appreciably from design levels the mater shall be referred to the client.

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 subbase materials 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 Items 103, 106, 107 and 108 respectively shall be the number of cubic 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 prismoidal 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.

ITEM 101 CLEARING AND GRUBBING

101.1 DESCRIPTION

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.

101.2 CONSTRUCTIONREQUIREMENTS

101.2.1 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.

Operation of clearing and grubbing shall in no way be deemed of effect 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 item 103 or for compaction under item 104, Compaction of Natural Ground, 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 of 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.

101.2.2 Protection and Restoration

The Contractor shall prevent 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 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.

101.3 MEASUREMENT AND PAYMENT

101.3.1 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 number of square meters 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.

Engineer shall ensure that a minimum of 500 SM area is designated for clearing and grubbing in any stretch of roadway for the sake of ease to construction activities.

Clearing and grubbing carried out by the Contractor in roadway cut areas and borrow pits shall be measured for payment.

101.3.2 Payment

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

Pay Item No.	Description	Unit of Measurement
101	Clearing and Grubbing	SM

ITEM 104 COMPACTION OF NATURAL GROUND

104.1 DESCRIPTION

The natural ground or surface ready for construction purposes after clearing and grubbing, or stripping, (if required) will be considered as (natural) Ground for the purpose of this item. The compaction of natural ground shall be carried out through a written order by the Engineer.

104.2 CONSTRUCTION REQUIREMENTS

Up to a depth of twenty (20) cm below the natural ground, all sods and vegetable matters shall be removed and clear surface shall be broken up by ploughing and scarifying to compact to the degree as defined below:-

For height of Embankment below sub grade level.	Percent of Maximum Dry Density as determined by AASHTO T-180.*
0 to 30 cm	95
30 to 75 cm	93
Over 75 cm	90
Below the foundation of structures	95

104.2.1 Compaction of original ground surface in areas of high water levels and salinity

Compaction of the natural ground surface in such areas will be difficult if not impossible. See Items 108, etc. under Formation of Embankment for construction requirements under these conditions, where compaction of Natural Ground shall not be carried out.

104.3 MEASUREMENT AND PAYMENT

104.3.1 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 meter.

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.

104.3.2 Payment

The payment under this item shall be made for at the contract unit price for Square meter 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.

Pay Item No.	Description	Unit of Measurement
104	Compaction of Natural Ground	SM

ITEM 106 EXCAVATION OF UNSUITABLE OR SURPLUS MATERIAL

106.1 DESCRIPTION

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, construction requirements and payment shall be covered under relevant Provisions.

106.2 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 Item 108.3.1. 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 can not be removed with Ripper of a 200 H.P. Bulldozer and constitutes a firm and continuous bed of rock only.

b) **Medium Rock**

Any rock which can not be removed with the blade of 200 H.P. 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 H.P. Bulldozer. This item will be termed as Soft Rock, irrespective of the fact that it is removed by blasting.

106.3 MEASUREMENT AND PAYMENT

106.3.1 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 a 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 pay Item No. 106a, 106b, 106c, and 106d as the case may be.

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 under mentioned Pay Item Nos. 106a, 106b, 106c, and 106d 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.

106.3.2 Payment

The quantities determined as provided above shall be paid for at the contract unit price respectively for each of the particular pay Items listed below and shown in the 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.

Pay Item No.	Description	Unit of Measurement
106a	Excavate Unsuitable Common Material	CM
106b	Excavate Unsuitable Rock Material	
	i. Hard Rock	CM
	ii. Medium Rock	CM
	iii. Soft Rock	CM
106c	Excavate Surplus Common Material	CM
106d	Excavate Surplus Rock Material	
	i. Hard Rock	CM
	ii. Medium Rock	CM
	iii. Soft Rock	

ITEM 107 STRUCTURAL EXCAVATION AND BACKFILL

107.1 DESCRIPTION

Structural excavation shall include the removal of ail 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 plans 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 at 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.

107.2 MATERIAL REQUIREMENT FOR BACKFILL

107.2.1 Backfill around structure

Backfill around structure shall be made with the following material.

a. Granular backfill of selected material as specified here under
b. Common backfill shall be carried out from excavated material or any other borrow material approved by the Engineer.

107.2.2 Grading backfill

Granular backfill material shall meet the following requirements.

a) Grading Requirement

mm	Inch.	A	B
25	V1	100	100
19	3 / 4”	60-100	75-100
4.75	No.4	50-85	55-100
2.0	No.10	40-70	40-100
0.425	NO.40	25-45	20-50
0.075	No.200	0-15	5-15

b) Material satisfying the requirements of coarse sand failing udder. soil classification A-3 (AASHTO). In case, coarse sand is utilised 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 size (6) as determined by AASHTO T-89 and T-90.

107.2.3 Common backfill

Use of excavated material as backfill may be allowed under this item. Use of borrow material for common backfill shall be allowed subject to approval of borrow material by the Engineer.

107.2.4 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.

107.3 CONSTRUCTIONREQUIREMENTS

107.3.1 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, backforms 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 item 106.2 of General Specifications.

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**

i) 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.

ii) 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.

e) **Cofferdams and Cribs**

i). 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.

ii). Cofferdams and cribs 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 p roper performance of the work which must be done inside them. In general, the interior dimensions of cofferdams and cribs 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 cribs, 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.

iii) 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.

iv) 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.

v) Unless otherwise provided, cofferdams of 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**

i) 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.

ii) Pumping to unwater a sealed cofferdam shall not commence until the seal has set sufficiently to with stand 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.

In case if an existing structure is to be replaced with a new structure the quantities for dismantling the structure shall be paid under item 510 (Dismantling of structures) and additional excavation required shall be carried out under this item.

h)**Classification of Excavation**

Classification of excavation shall be made as described under items 106.2 of this Specification.

107.3.2 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 20 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 the item 108.3.1. Moisture content shall be adjusted as directed by the Engineer. Proper benching shall be made to ensure bonding of existing and n6w 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. also if sand or granular backfill is used by the contractor for his convenience, no extra payment will be made.

107.3.3 **Backfill**

a) Granular backfill where-ever directed shall be placed in the position and in 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 twenty (20) 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) centimeters 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, where as 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 twenty (20) cms in depth to the density, 95 percent of maximum dry density, as per AASHTO T- 80 (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) centimeters. 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 ail bridge structures shall be deposited in well-compacted, horizontal layers not to exceed twenty (20) cm. in thickness. The common backfill in front of such units shall be placed first to prevent the possibility of forward movement.

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.

f) 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 equipments to ensure compaction in restricted areas, Engineer may allow backfill with sand saturation method, at no extra cost to the Client.

g) Adequate provision shall be made for the through drainage of all backfill. French drains shall be placed as weep holes.

h) No backfill shall be placed against concrete or masonry structure before fourteen (14) days of placement and backfilling shall be carried out on both sides of the structure simultaneously.

107.4 MEASUREMENT AND PAYMENT

107.4.1 Measurement

a) **Structural Excavation**

The quantities of structural excavation to be paid for shall be the number of cubic meters 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:-

1) The vertical limits for computing pay quantities will be vertical planes 50 centimeters outside of the neat lines of footings or foundations as shown on the Drawings or as directed by the Engineer.

2) 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.

3) 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 of material laid and compacted in place within the fine of structure and limits defined in Item 107.4.1 (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 of material laid and compacted, placed within the lines of structure and limits defined in Item 107.4.1(a) above and accepted by the Engineer.

107.4.2 Payment

The quantities determined as provided above shall be paid for at the contract unit price respectively for each of the particular pay item listed below that is shown in the 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.

Pay Item No.	Description	Unit of Measurement
107a	Excavate Excavation in Common Material	CM
107b	Excavate Excavation in Common Material Below Water Level	CM
107c	Excavate Excavation in Rock Material	
	i. Hard Rock	CM
	ii. Medium Rock	CM
	iii. Soft Rock	CM
107d	Granular Backfill Type-	CM
107e	Common Backfill	CM

ITEM 108 FORMATION OF EMBANKMENT

108.1 DESCRIPTION

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 plans r established by the Engineer.

108.2 MATERIAL REQUIREMENTS

Material for embankment shall consist of suitable material excavated from borrow, 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 material shall not be less than five (5) percent, determined in accordance with AASHTO TA 93. CBR value shall be obtained at a density corresponding to the degree of compaction required for the corresponding layer.

c) Swell value of the material for embankment formation shall not exceed five tenth (0.5) 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.

108.3 CONSTRUCTION REQUIREMENTS

108.3.1 Formation of Embankment with Borrow 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 20 cm. thick, unless otherwise allowed by the Engineer after a trial section is prepared and approved.

The material placed in layers and that scarified to the designated depth for formation of embankment shall be compacted to the density specified below:

Depth in centimeters below subgrade level	**Percent of Maximum Dry Density as determined by AASHTO T-180.***
0 to 30	95
30 to 75	93
Over 75	90

***** 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/ 19 mm sieve), the in-place density thus obtained shall be adjusted to aecount 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 centimeters thick and compacted to the densities specified above by the use of mechanical tempers, 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.

108.3.2 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 d6wn 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) centimeters of loose measurement and compacted by a vibratory roller with the minimum mass as shown in the following table.

Mass per meter width of vibrating roll (Kg / M)	Depth of fill layer (mm)	Number of passes of the roller on each layer
2300 – 2900	400	5
2900 – 3600	500	5
2600 – 4300	600	5
4300 – 500	700	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, clean small spells, 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) centimeters. 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) centimeters in any dimension shall be placed in the top fifteen (15) centimeters 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 that 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.

108.3.3 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) centimeters 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.

108.3.4 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 item 106a.

108.3.5 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 following specifications:

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 subgrade or natural ground surface material. For this condition to be met it will be required that the ratio.

$$\frac{D_{15}\text{(Working Platform Material)}}{D_{85}\text{ (Natural Ground Material)}} \text{ is less than 5.}$$

D_{85} and D_{15} 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 meter 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 Item 108.3.1.

108.3.6 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 materials 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.

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.

108.4 MEASUREMENT AND PAYMENT

108.4.1 Measurement

The quantities to be paid for shall be the number of cubic meters calculated on theoretical designed lines and grades and the ground levels as established under clause 100.9, compacted in place, accepted by the Engineer formed with material resulting from:

i) Formation of Embankment from Borrow Excavation

Measurement shall be made as under:-

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

ii) 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.

iii) 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, the payment will still be made under this item 108 (a) & 108 (b).

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.

108.4.2 Payment

a)**Formation from Borrow Excavation.**

The quantity to be paid for shall be the number of cubic meters 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 meters 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 meters placed in embankment and measured as provided above for material form 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.

Pay Item No.	Description	Unit of Measurement
108a	Formation of Embankment from Roadway Excavation in Common Material	CM
108b	Formation of Embankment from Roadway Excavation in Rock Material	CM
	i. Hard Rock	CM
	ii. Medium Rock	CM
	iii. Soft Rock	CM
108c	Formation of Embankment from Borrow Excavation in Common Material	CM
108d	Formation of Embankment from Structural Excavation in Common Material	CM
108e	Formation of Embankment from Structural Excavation in Rock Material	CM
	i. Hard Rock	CM
	ii. Medium Rock	CM
	iii. Soft Rock	CM

ITEM 109 SUBGRADE PREPARATION

109.1 DESCRIPTION

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

109.2 CONSTRUCTION REQUIREMENT

109.2.1 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) centimeters of existing subgrade level or all structures which will be below thirty (30) centimeters of newly placed subgrade level, shall be in such operative conditions as to ensure prompt and effective drainage and to avoid damage to subgrade by surface water. No work of subgrade preparation will be started before the prior work herein described have been approved by the Engineer.

109.2.2 Compaction Requirement

All materials down to a depth of 30 cm below the subgrade 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 V whichever is applicable, or corresponding Relative Density as per D4254-83 (ASTM).

109.2.3 Subgrade Preparation in Earth Cut

In case bottom of subgrade level is within thirty (30) cm of the natural ground, the 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 subgrade layer is thirty (30) cm.

In case, the bottom of subgrade 4 s below the natural ground by more than Thirty (30) cm, the material above the top of subgrade 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 pay Item 106a and for replacement of approved material, the payment will be made under pay Item 108c.

109.2.4 Subgrade Preparation in Rock Cut

Excavation in rock shall extend to the subgrade level as shown on drawings. Rock shall be undercut nearly to required elevation and sections shown on the plans or as directed by the Engineer. Transverse and longitudinal profiles checked by template shall be accurate to the requirement. Cuts below subgrade level shall be backfilled with selected subbase material and compacted to minimum ninety eight (98) percent of the maximum dry density as determined by AASHTO T-180, method U. 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) centimeters above the under cut section elevation. The under cut material shall be placed in embankment or disposed of at the direction of Engineer.

109.2.5 Subgrade in Embankment

When the subgrade 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) centimeters below subgrade level shall meet compaction requirement of 109.2.2. Soils having a minimum value of C.B.R of seven (7) percent and swell value of not more than 0.3 percent shall be used. C.B.R less than seven *(*7)% may be used in case, the design allows for it. 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 equipments 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 equipments 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 108a, through 108e, Formation of Embankment.

109.2.6 Subgrade 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 subgrade, the correct elevation on which the base or subbase 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 subgrade is within 30 cm of the existing ground/road then the item shall be measured and paid accordingly.

109.2.7 Subgrade reinforcement

When the width of the existing pavement, either to be scarified or not, is insufficient to contain the subbase or base to be placed upon it, the Engineer may order to strengthen and support the subbase 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 No. 108a; if declared unsuitable it shall be disposed of and paid as provided in Item 106a. The finished compacted surface of the subgrade shall be as specified in Item 109.2.3.

109.2.8 Protection of Compacted Work

Any part of the subgrade 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 subgrade. 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 subgrade preparation to an area easily maintained with the equipment available. Subgrade preparation and subbase or base placing shall be arranged to follow each other closely. The subgrade, when prepared too soon in relation to the placing of the subbase, is liable to deteriorate, and in such case the Contractor shall, with ' out additional payment, repair, reroll, or recompact the subgrade as may be necessary to restore it to the state specified herein.

109.2.9 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 subgrade levels have been checked and approved by the Engineer. For tolerances, referred to the, 'Table for Allowable Tolerances" in these specifications.

109.3 MEASUREMENT AND PAYMENT

109.3.1 Measurement

The quantity to be paid for shall be the number of square meters of subgrade prepared as herein before prescribed and accepted. Subgrade in rock cuts and on embankment not consisting of the existing road surface in fill area shall not be measured for direct payment.

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

109.3.2 Payment

The quantities, determined as provided above, shall be paid for at the contract unit price respectively, for each of the particular pay items listed below that is shown in the Bill of Quantities which prices and payment shall be full compensation for furnishing of material, water, equipment, tools, labour, and all other items necessary for completion of work.

Pay Item No.	Description	Unit of Measurement
109a	Subgrade preparation in Earth Cut	SM
109b	Subgrade preparation in Existing Cut	
	i. Without any fill	SM
	ii. With fill less than 30 cms	SM

ITEM 201 GRANULAR SUBBASE

201.1 DESCRIPTION

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.

201.2 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 A, B, and C given below. However grading A may be allowed by the Engineer in special circumstances.

Grading Requirement for Subbase Material

Sieve Designation		Mass Percent Passing Grading	
Mm	**Inch**	**A**	**B**
60.000	(2.1/2)	100	--
50.000	(2)	90-100	100
25.000	(1)	50-80	55-85
9.500	(3/8)	--	40-70
4.750	No.4	35-70	30-60
2.000	No.10	--	20-50
0.425	No.40	--	10-30
0.075	No.200	2-8	5-15

The Coefficient of Uniformity D60/D10 shall be not less than 3, where D60 and D10 are the particle diameters corresponding to 60% and 10%, respectively, passing (by weight) in a grain size analysis, curve.

b) The Material shall have a CBR value of at least 50%, 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.

c) 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.

d) 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.

e) 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.

f) If over-size is encountered, screening 6f material at source, shall invariably be done, no hand picking shall be allowed, however hand picking may be allowed by the Engineer, if over-size quantity is less than 5% of the total mass.

g) Sand equivalent for all classes shall be 25 min.

201.3 CONSTRUCTIONREQUIREMENTS

201.3.1 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 z one half (7.5) centimeters 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.

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 Table for Allowable Tolerances" 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.

201.3.2 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. For details, refer to clause 1.20 (General) of these specifications.

201.3.3 Compaction

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

The subbase material shall be compacted by means of approved vibrating rollers or steel wheel rollers (rubber tyred rollers may be used as a supplement), progressing gradually from the outside towards the centre, except on superelevated curves, where the roiling shall begin at the low side and 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 shaped and dressed 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 conform to the required finish, the Contractor shall, at his own expense, rework, water, and recompact the material before succeeding layer of the pavement structure is constructed.

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 bladed or otherwise dressed to conform to the lines and dimensions shown on the plans.

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

201.3.4 Compaction requirements

The relative compaction of each layer of the compacted subbase shall not be less than Ninety eight (98) percent of the maximum 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 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

201.3.5 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.

a) Same size of sample is placed in oven for moisture determination in case of laboratory density (Proctor) and field density.

b) Moisture content for calculation of field density and proctor shall be observed on material passing 4.75 mm sieve.

201.3.6 Tolerance

The subbase shall be compacted to the desired level and cross slopes as shown on the drawings. The allowable tolerance shall be according to the “Table for Allowable Tolerances" in these specifications.

201.4 MEASUREMENT AND PAYMENT

201.4.1 Measurement

The quantity of subbase to be paid for shall be measured 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 materials placed outside the theoretical limits as shown on the cross-sections.

201.4.2 Payment

The accepted quantities measured as provided above shall be paid for at the contract unit price per cubic meter of granular subbase, for the Pay Item listed below and shown in the Bill of Quantities, 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.

Pay Item No.	Description	Unit of Measurement
201	Granular Subbase	CM

ITEM 202 AGGREGATE BASE COURSE

202.1 DESCRIPTION

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

202.2 MATERIAL REQUIREMENTS

Material for 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 A or B given below.

Grading Requirement for Aggregate Base Material

Sieve Designation		Mass Percent Passing Grading	
mm	Inch	A	B
50.000	2	100	100
25.000	1	70-95	75-95
9.500	$^3/_8$	30-65	40-75
4.750	No.4	25-55	30-60
2.000	No.10	15-40	20-50
0.425	No.40	8-20	12-25
0.075	No.200	2-8	5-10

The material shall be well graded such that the coefficient of Uniformity D60/D10 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 shall have a Liquid limit of not more than twenty five (25) and a plasticity Index of not more than 6 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.

202.2.1 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 pugmill 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.

AASHTO Sieve	Percent Passing
3/8 Inch	100
4	85-100
100	10-30
Plasticity Index (AASHTO T-90)	6 maximum
Sand Equivalent (AASHTO T-176)	30 minimum

However the combined aggregates prepared by mixing the coarse material and filler shall satisfy the requirements as mentioned in clause 202.2 above.

202.3 CONSTRUCTIONREQUIREMENTS

202.3.1 Preparation of surface for 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 or moisture in excess to optimum moisture content.

Spreading shall conform in all respects to the requirements specified under this heading in Item 201 - Subbase (201.3.1).

202.3.2 Compaction

Compaction process shall conform in all respect to the requirements specified under this heading in Item 201 (201.3.3).

202.3.3 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-1 80, Method D (Modified). 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 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.

202.3.4 Moisture Content Determination

Moisture content determination shall conform in all respects to the requirements specified under clause 201.3.5 for subbase.

202.3.5 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 of material. For details refer to clause 1.20 (General) of these specifications.

202.3.6 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 the "Table for Allowable Tolerances" in these specifications.

202.3.7 Acceptance, Sampling and Testing

Acceptance of sampling and testing with respect to materials and construction requirements shall be governed by the relevant, “Table for Sampling and Testing Frequency” or as approved by the Engineer.

202.4 MEASUREMENT AND PAYMENT

202.4.1 Measurement

The quantity of aggregate base to be paid for, shall be measured 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.

202.4.2 Payment

The accepted quantities measured as above shall be paid for at the contract unit price per cubic meter of aggregate base, for the item listed below and shown in the Bill of Quantities, 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.

Pay Item No.	Description	Unit of Measurement
202	Aggregate Base	CM

ITEM 206 WATER BOUND MACADAM BASE

206.1 DESCRIPTION

This work shall consist of furnishing and placing one or more courses of clean crushed stone base mechanically interlocked by rolling, and voids thereof filled with screening and binding material with the assistance of water, laid on a prepared subgrade, sub base, or exiting pavement in conformity with the lines, grades and cross-sections shown on the drawings.

Unless otherwise directed by the Engineer this item of work may be applied to road structure or shoulders.

206.2 MATERIAL REQUIREMENTS

Coarse aggregates either crushed or broken stone s all conform to the quality requirements as specified hereunder, except that no C-BR testing will be required. The gradation curve of the coarse aggregate shall be within the envelope limits given below:-

Sieve Designation		Percent Passing by weight		
mm	Inch	Class A	Class B	Class C
102	(4")	100		
89	(3.1/2")	90-100		
76	(3")	-	100	
63.5	(2.1/2")	25-60	90-100	100
50	(2")	-	25-75	90-100
37.5	(1.1/2")	0-15	0-15	35-70
25	(1")	-	-	0-15
19	(3/4")	0-5	0-5	0-5
12.5	(1/2")	-	-	-

Fine aggregate (filler material or screening shall consist of crushed stone screenings or any other fine material approved by the Engineer. It shall be free from clay lumps, dirt and other objectionable material. The fine aggregate shall be of the following gradation.

Sieve Designation		Percent Passing by weight
mm	Inch	
9.5	3/8	100
4.35	No.4	85-100
0.15	No.100	10-30

The material passing No. 40 sieve shall have a liquid Limit of not more than twenty five (25) and a Plasticity Index of not more than six (6).

206.2.1 Physical Requirements

The additional physical requirements of coarse aggregates for water bound macadam will satisfy the following limits:-

a. Loss Angeles Abrasion Value Max 45%
b. Flakiness Index Max 15%
c. The loss when subject to five cycles of the Sodium Sulphate Soundness test (AASHTO T-104) shall be less than twelve (12).

206.2.2 Binding Material

Binding material to prevent ravelling of water bound macadam shall consist of a fine grained material passing 100 percent through 425 micron sieve and possessing P.1 value of four to nine (4-9) when the Water Bound Macadam (WBM) is to be used as a surfacing course, and upto 6 when WBM is being adopted as sub-base / base course with bituminous surfacing. If lime stone formations are available nearby, lime stones dust or as directed by the Engineer, may be used fully employed for this purpose.

206.3 CONSTRUCTION REQUIREMENTS

206.3.1 Equipment

Any combination of machines or equipment that will produce the results meeting these specifications may be used with the approval of the Engineer. These include mechanical spreaders, water sprinklers and rollers/compactors.

206.3.2 Structure Preparation

Preparation of surface for water bound macadam, shall be carried out in the same manner as for aggregate base course item 202.3.1.

Where the existing road surface is black topped, 50 mm x 50 mm furrows shall be cut in the existing surface at one (1) meter intervals at forty five (45) degree to the centre line of the carriage-way before proceeding with the laying of coarse aggregates.

Before starting with WBM Construction, necessary arrangements shall be made for the lateral confinement of aggregates. One method is to construct side shoulders in advance to a thickness corresponding to the compacted layer of the WBM course. After shoulders are ready, there inside edges may be trimmed vertical and the included area cleaned 11 spilled material thereby setting the stage for spread of coarse aggregates. The practice of constructing WBM in a trench section excavated in the finished formation must be avoided.

206.3.3 Spreading and Compaction

Crushed stone shall be deposited and spread on the prepared surface to the proper depth so that the compacted layer will not exceed two and a half (2.1/2) times the thickness of maximum aggregate size. Each layer shall be inspected thoroughly before rolling to detect high or low spots. Crushed stones shall be added or shifted to provide a true surface. The course aggregate layer, after being laid to proper thickness, shall be lightly rolled sufficient only to establish the required grade and level of the stones.

Spreading of the coarse aggregates shall be followed by rolling with a smooth wheel roller weighing at least 10 tons. Rolling shall begin at the lower edge of the shoulders to lock the stones firmly at the edge, then progress gradually towards the centre line. Rolling shall continue until the aggregate is well keyed and does not creep ahead of the roller.

In no case, shall coarse aggregates be stored in heaps directly on the area where these are to be laid nor shall them hauling over a partly completed base be permitted, however dumpers shall be allowed at the construction area where the material will be spreaded quickly after dumping.

Following the initial rolling, dry screenings shall be applied uniformly over the surface. Dry rolling shall be continued while screenings are being applied. The surface shall be swept with mechanical or hand brooms to aid spreading of the screenings.

When the interstices in the coarse aggregate are filled with screenings, the surface shall be sprinkled with water until it is saturated. The rolling, sprinkling and application of additional screenings shall continue until a grout is formed that fills all the voids and forms a wave of grout in front of the roller.

When more than one layer is required to complete the Macadam base course to the thickness shown on the drawings, each layer shall be constructed as before prescribed.

206.3.4 Construction Control Testing

Tests for compliance with the requirements of Item 206.2 will be made as often as deemed necessary and to the satisfaction of the Engineer.

206.3.5 Maintenance

The completed base course shall be maintained in an acceptable condition until the necessary subsequent treatment is applied.

206.4 MEASUREMENT AND PAYMENT

206.4.1 Measurement

The quantity of Water Bound Macadam Base to be paid for shall be measured 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 Waterbound Macadam Base Course. No allowance will be given for materials placed outside the theoretical limits shown on the cross-sections.

206.4.2 Payment

The accepted quantities measured as provided above shall be paid for at the contract unit price per cubic meter of Water Bound Macadam Base, for the pay items listed below and shown in the Bill of Quantities, 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.

Pay Item No.	Description	Unit of Measurement
206a	Water Bound Macadam Base with Coarse Agg: Class A	CM
206b	Water Bound Macadam Base with Coarse Agg: Class B	CM
206c	Water Bound Macadam Base with Coarse Agg: Class C	CM

ITEM 302 BITUMINOUS PRIME COAT

302.1 DESCRIPTION

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, waterbound base course, crushed aggregate base course, tops of roadway shoulders, and as otherwise shown on the plans in strict accordance with the specification and in conformity with the lines shown on the drawings.

302.2 MATERIAL REQUIREMENTS

Asphaltic material shall conform to the requirements of the item 301- “Asphaltic Materials", either cutback or Emulsified Asphalt, which ever is specified in the Bill of Quantities.

302.3 CONSTRUCTION REQUIREMENTS

Prime coat shall be applied when the surface to be treated is dry; except that when emulsified asphalt is used, the surface may be reasonably moist. 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. Prior to the application of the prime coat, all loose materials shall be removed from the surface and the same shall be cleaned by means of approved mechanical sweepers or blowers and/or hand brooms, until it is as free from dust as is deemed practicable. No traffic shall be permitted on the surface after it has been prepared to receive the bituminous material. Prior to the application of prime coat on bridge decks and concrete pavements, the surfaces shall be cleaned of all loose material as described in Section 302.3. 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:

(i) The top of earth surface or water bound base courses from a point twenty (20) centimeters outside the edge of the pavement line to 20 cms outside the line on the opposite side of the roadway.

(ii) The top of the shoulders from the inter-section of embankment slope and top pf subgrade to the edge of the pavement line.

(iii) The bridge wearing surface from curb to curb and end to end of bridge wearing surface.

(iv) Other surfaces as shown on the plans 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.

302.3.1 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) M. 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 meter 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 meter 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.

302.3.2 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 Item 301 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 under:

TYPE OF SURFACE	**LITRES PER SQUARE METER**	
	Minimum	**Maximum**
1. Subgrade, Subbase, Water bound base course, and Crushed stone base course.	0.65	1.75
2. Bridge, Wearing Surfaces, Concrete Pavement	0.15,	0.4

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 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.

302.4 MEASUREMENT AND PAYMENT

302.4.1 Measurement

The unit of measurement shall be square meter 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 plans or designated by the Engineer.

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

302.4.2 Payment

The payment for area primed measured as stated above, shall be made for the contract unit price per SM, 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:

Pay Item No.	Description	Unit of Measurement
302	Bituminous Prime Coat.	SM

ITEM 304 BITUMINOUS SURFACE TREATMENT AND SEAL COAT / PAD COAT

304.1 DESCRIPTION

This work shall consist of one or more applications of asphaltic material and one or more covers of aggregates or an application of asphaltic material without aggregates applied in accordance with these specifications and in conformity with the lines and width shown on the typical cross-sections or as established by the Engineer.

304.2 MATERIAL REQUIREMENTS

304.2.1 Aggregate

Aggregate shall consist of clean, dry, hard, durable, tough, angular, sound crushed stone or crushed gravel of uniform quality, and free from dirt, clay and other objectionable matter. Aggregates from only the sources of established adhesion properties would be used. The percentage of wear by the Los Angeles Abrasion test (AASHTO T-96) shall not be more than forty (40). Aggregate crushing value (ACV) when tested as per BS-812 (1990) shall not exceed 25%. When subjected to five (5) cycles of sodium-sulfate soundness testing as determined by AASHTO T-104, it shall have a weight loss of not greater than ten (10) percent. The moisture content in the aggregate applied directly to the surface of the bituminous material shall not exceed three (3) percent by weight plus one-half (1/2) the water absorption of the aggregate at the time of delivery to the Project. In no case shall free moisture be drawing from the truck bed.

The portion of aggregate retained on the 9.5 mm (3/8 inch) sieve shall not contain more than fifteen (15) percent of particles by weight of flat or elongated, or both, that the ratio between the maximum and the minimum dimensions exceeds 2.5:1. Flakiness Index, tested under BS-812 (1990) part 105, shall be 25 (max) for nominal size 18 mm and 12 mm and 30 (max) for nominal size 9mm.

The nominal sizes of aggregates used for surface treatment; shown against table 304-1 shall be as under:

Size No.1 - Nominal size 18 mm
Size No.2 - Nominal size 12 mm
Size No 3 - Nominal size 9 mm
Size No.4 - Nominal size 6 mm

The nominal size are defined in the table below:

Nominal Size (mm)	Specified Size *			
	Passing		Retained	
	Sieve (mm)	%age	Sieve (mm)	%age
18	19	100	12.5	85
12	12.5	100	9.5	85
9	9.5	100	6.3	85
6	6.3	100	4.75	85

***** By convention, this item defines a fraction of material within the respective sieves.

For Material passing 31W Sieve, following Table shall be used:

Sieve Designation		Percent Passing by Weight			
Mm	**Inch**	**Size No.1**	**Size No.2**	**Size No.3**	**Size No.4**
9.5	3/8	0-15	0-10	-	-
4.75	No.4	0-5	0-5	0-10	-
2.38	No.8	-	-	0-5	0-5
1.18	No.16	-	-	-	0-3
0.75	No.200	0-2	0-2	0-1	0-1

304.2.2 **Asphaltic Material**

The asphaltic material shall conform to the requirements of Item 301 'Asphaltic Materials'. The type shall be one of the following, as shown in the Bill of Quantities or ordered by the Engineer. Spraying temperature shall be as shown against each type.

Table: Spraying Temperatures (^{O}C) for Surface Treatments

Asphalt Type / Grade Spraying Temperature	Spraying Temperature Surface Treatments
a. Asphalt Cements	
AC-2.5.	130 min.
AC-5	140 min.
AC-10	140 min.
AC-20	145 min.
AC-40	150 min.
AR-1000	155 min.
AR-2000	140 min.
AR-4000	145 min.
AR-8000	145 min.
AR-16000	-
200-300 pen.	130 min.
120-150 pen.	130 min.
85-100 pen.	140 min.
60-70 pen.	145 min.
40-50 pen.	150 min.
b. Emulsified Asphalts	
RS-1	20-60
RS-2	50-85
MS-1	20-70
MS-2	-
MS-2h	-
HFMS-1	20-70
HFMS -2	-
HFMS -2h	-
HFMS -2s	-
SS-1	-
SS-1h	-
CRS-1	50-85
CRS-2	50-85
CMS-2	-
CMS-2h	-
CSS-1	-
CSS-1h	-

Asphalt Type / Grade Spraying Temperature	Spraying Temperature Surface Treatments
c. Cutback Asphalts (RC, MC, SC)	
30 (MC only)	30 min.
70	50 min.
250	75 min.
800	95 min.
3000	110 min.

304.3 CONSTRUCTIONREQUIREMENTS

At the time of the application, the weather shall be warm and dry, and the road surface shall be clean and dry. Spraying shall not be done unless the road temperature is above twenty (20) degree C for at least one hour prior to the commencement of spraying operations, and the temperature shall not be less than twenty (20) degree C during the spraying. Prior to applying the asphaltic material, dirt and other objectionable materials shall be removed from the surface and surface shall be primed as per item 302.. If so directed by the Engineer, the surface shall be cleaned by power brooming or wire brush until all loose and foreign materials are removed.

304.3.1 Equipment

Equipment shall conform in all respects to the provisions under Item 302.3.1. The equipment shall be operated by # the manpower specially trained for this work. Necessary safety arrangement for the workers, equipment and traffic shall be ensured during the operations.

304.3.2 Preparation of Surface

Irregularities and surface damage e.g. pot-holes, depressions, ravelling, shall be corrected prior to surface dressing. The Engineer shall also satisfy himself that fundamental pavement defects e.g. base failure, drainage problems etc. have been remedied before surface dressing is attempted. Areas, which are excessively rich in bitumen e.g. 'bleeding', shall be cut out and patched. All patches, however, occasioned shall be thoroughly compacted, sealed and blinded with crusher dust before opening to traffic for several days before surface dressing commences.

Immediately prior to the application of binder all dirt, dust are foreign material shall be removed by thorough brooming and 1 or the use of compressed air. Adhering mud or other soiling may be removed using water and brushes, the general use of water to wash the road shall not be permitted.

304.3.3 Application of Asphaltic Materials

Asphalt cement, liquid asphalt and emulsified asphalt shall be applied by means of pressure distributor manual or automatic at the temperature specified for the type and grade of asphalt being used. The rates of application shall be within the ranges given in Table 304-1.

The spread of bituminous materials shall be at least ten (10) cm more than the width to be covered by the aggregate from the spreading device. The distributor shall be moving forward at proper application speed at the time the spray bar is opened. Any skipped areas or deficiencies shall be corrected in an approved manner. Junctions of spreads shall be carefully made to assure a smooth riding surface. The length of spread of bituminous material shall not exceed than that which trucks loaded with cover coat material can immediately cover. Under no circumstances shall operations proceed in such manner that bituminous material will be allowed to chill, set up, dry, or otherwise impair retention of the cover coat.

The distributor when not spreading shall be so designed that the spray bar or mechanism Will not drip bituminous material on the surface of the travelled way. Distribution of the bituminous material shall be so regulated and sufficient bituminous material left in the distributor at the end of each application, so that there will be a uniform distribution of bituminous material. In no case shall the distributor be allowed to expel air with the bituminous material thereby causing uneven coverage. The angle of the spray nozzles and the height of the spray bar shall be so adjusted and frequently checked that uniform distribution is ensured. The distribution shall cease immediately upon any clogging or interference of any nozzle and corrective measures shall be taken before distribution is resumed.

304.3.4 Spreading of Aggregate

Immediately after applying the asphaltic material, dry aggregate shall be uniformly and evenly distributed over the treated surface from an approved mechanical aggregate spreader or any other means approved by the Engineer. The truck carrying the aggregate shall move backward as it spreads same, so as to prevent the tyres ~of the truck and the mechanical aggregate spreader from driving directly on the newly sprayed asphalt. No portion of the binder shall remain uncovered for a period in excess of twenty (20) minutes after spraying.

Immediately after spreading of the aggregate, the treated surface shall be rolled with a self-propelled pneumatic-tyre roller having a minimum contact pressure of 2.8 Kg/square centimeter. A steel-wheeled roller weighing between six (6) to eight (8) tons may be used as a second roller. Rolling shall continue only until a smooth, thoroughly compacted surface is obtained. Procedures of starting, stopping, or turning of any piece of equipment which results in displacement of the cover material or damage to the seal courses be prohibited.

Any place where binder shows on the surface shall, be covered with additional aggregate and further rolled and broomdragged until an even surface results, and does not adhere to Wheels of vehicles. Overlapping the applications of cover material shall be avoided and. all spillage shall be removed from the surface.

The quantity of aggregates to be applied shall be within the ranges specified in Table 304.1.

304.3.5 Maintenance of Traffic

Detouring of highway traffic for this work on running road will not be provided for or permitted, except when authorized by the Engineer. All construction operations shall be coordinated to result in the least practicable delay of traffic. One way traffic shall be maintained and traffic speeds restricted to fifteen (15) Km per hour. The contractor shall provide flagmen, warning signs, barricades, and a sufficient number of pilot cars to control traffic through the bituminous sealing operations when so directed by the Engineer. Pilot cars shall be used to lead the traffic through the areas of all distribution and sealing operations. Pilot cars shall be light "Pick up" trucks or other approved vehicles and shall be equipped with signs reading "PILOT CAR - DO NOT PASS in both English and Urdu languages. Two (2) signs shall be mounted on the vehicles so as to be clearly Visible from both directions. One (1) flagman shall be stationed immediately ahead of the application of the bituminous material and one (1) flagman immediately behind the section being rolled. Suitable speed limit signs shall be displayed, and the signs shall move forward with the flagman as the work progresses.

No separate payment shall be made for conformance to this paragraph. All these items being considered subsidiary to the item (s) given in the Bill of Quantities.

304.3.6 Working Period

All work shall be so conducted 1hat the work of applying asphalt and aggregate and of all rolling shall be completed during the time from sunrise to sunset and under favorable weather conditions as determined by the Engineer.

304.3.7 Maintenance of completed work

When directed by the Engineer, the Contractor will be required to add bituminous material or aggregate or both to the portion of road identified for such purpose on the project. Furnishing additional bituminous material and furnishing, spreading, dragging and rolling of additional aggregate will not be paid for separately but will be considered as subsidiary work pertaining to the relevant item of "Bituminous Surface Treatment".

304.3.8 Opening of Traffic and after-care

There shall be no delay in opening a completed surface dressing to traffic at a controlled speed. Prior to opening to traffic any spillage of aggregates shall be removed and any binder drips or wind blown contamination shall be dusted with crusher waste. After 2-3 days under traffic, excess stone will be removed by brushing.

304.3.9 Pad Coat

To ensure chipping retention when surface dressing a very hard surface, a pad coat consisting of application of an initial binder spray followed by 6 mm. chipping will be applied. After stabilizing of pad coat under traffic, the 3ppropriate surface dressing will be applied.

304.4 MEASUREMENT AND PAYMENT

304.4.1 Measurement

The quantity of surface treatment to be paid for shall be measured in square meter within the theoretical line in place as shown on drawing. No allowance will be given for material placed outside the theoretical limits of finished surfacing whether placed for, due to requirement of contractor's operations or placed out side the limits due to inadequate control.

304.4.2 Payment

The aggregate and asphaltic material measured as stated above shall be paid for at the contract unit price per square meter for a particular item listed below and shown on the bill of quantities, which payment shall be full compensation for furnishing all labour, materials, tools equipment and incidental for performing all the work in the construction of bituminous surface treatment or seal coat complete in place and according to specification, including priming of surface.

Pay Item No.	Description	Unit of Measurement
304 a	Single Surface Treatment	SM
304 b	Double surface Treatment	SM
304 c	Triple Surface Treatment	SM
304 d	Seal Coat 1 Pad Coat	SM

TABLE 304-1
Quantities of Materials for Bituminous Surface Treatments

Surface Treatment		Aggregate		Bituminous Material	
Type	Application	Size No.	Quantity Kg. / Sq.M	Quantity Litres / Sq.M	Type
Single	Single	2	12.5	1.19	(a)
				1.63	(b)
Double	First	1	24.0	1.19	(a)
				2.14	(b)
	Second	3	12.5	1.19	(a)
				1.63	(b)
Tripple	First	1	24.0	1.90	(a)
				2.14	(b)
	Second	2	12.5	1.19	(a)
				1.63	(b)
	Third	3	6.5	0.68	(c)
Seal Coat / Pad Coat with Aggregate		4	4	0.5	(c)

Notes:-

i) Bituminous material types are (a) asphalt cement, (b) cut-back or emulsified and (c) asphalt cement, cut-back and emulsified.

ii) Quantities of bituminous material may be varied by the Engineer by + 15% depending on site conditions.

iii) Prime coat shall be applied prior to the surface treatment for the newly constructed pavement at the rate as specified in the item 302.3.2.

ITEM 305 ASPHALT CONCRETE WEARING COURSE – PLANT MIX

305.1 DESCRIPTION

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.

305.2 MATERIAL REQUIREMENTS

305.2.1 Mineral Aggregates

The Aggregates shall consist of coarse aggregates, fine aggregates and fitter 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 fro" 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 following gradation:

Sieve Designation		Percent Passing by Weight
mm	Inch	
0.600	No.30	100
0.300	No.50	95-100
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:

i. 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.

ii. 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).

iii. 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.

305.2.2 Asphaltic Material

Asphaltic binder to be mixed with the aggregate to produce asphaltic base shall be asphalt cement penetration grade 40-50, 60-70 or 80-100 as specified by the Engineer. Generally it will meet the requirement of AASHTO M-20.

305.2.3 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 shown in the following table:

Table 305-1
Asphalt Concrete Wearing Course Requirements

Mix Designation	Class A	Class B
Compacted Thickness	50-80 mm	35-60 mm
Combined Aggregate Grading Requirements		

Sieve Designation		Percent Passing by Weight	
Mm	**Inch**		
25	1	100	-
19	3/4	90-100	100
12.5	1/2	-	75-90
9.5	3/8	56-70	60-80
4.75	No.4	35-50	40-60
2.38	No.8	23-35	20-40
1.18	No.16	5-12	5-15
0.075	No.200	2-8	3-8

Asphalt Content weight percent of total mix	3.5 (Min.)	3.5 (Min.)

The asphalt concrete wearing course mixture shall meet the following Marshal Test Criteria:

Compaction, number of blows each end of specimen	75
Stability	1000 Kg (Min)
Flow, 0.25 mm (0.01 inch)	8-14
Percent air voids in mix	4-7
Percent voids in mineral aggregates	according to table 5.3 MS-2 (Asphalt Institute - USA), sixth addition, 1993.
Loss of Stability	20% (Max.)

305.2.4 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 J MF 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 305-1. 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 ^{o}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 with the following ranges of tolerances:

Combined aggregates -gradation

Retained No. 4 and larger	± 7.0%
Passing No. 4 to No. 100 sieves	± 4.0%
Passing No. 200	± 1.0%

Asphalt Content

Weight percent of total mix	± 0.3%

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.

305.3 CONSTRUCTIONREQUIREMENTS

Construction requirements for this Item shall conform with the same as specified for Asphaltic Concrete Base Course Plant Mix under Item 203.3, except as modified in the following sub-items.

305.3.1 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

305.3.2 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 ± 3mm 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 ten (10) mm, payment will be made at an adjusted price as specified in table-1, clause 305.4.2.(2) of this specification.

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) millimeters. The cross fall (camber) shall be with + 0.2 percent of that specified, and the level at any point shall be within + 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.

305.3.3 Acceptance Sampling and Testing

Acceptance of sampling and testing for this Item with respect to materials and construction requirements, not specified herein, shall be in accordance with the relevant, Tables for Sampling and Testing Frequency" in these specifications.

305.4 MEASUREMENT AND PAYMENT

305.4.1 Measurement

The quantities of Asphaltic wearing course shall be measured by volume in CM. laid and compacted in place. Measurements shall be based on the dimension as shown on plans or as otherwise directed or authorized by the Engineer. A tolerance of + 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 10 mm shall be paid as per clause 305.4.2 (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.

305.4.2 Payment

1) The quantity determined as provided above shall be paid for at the contract unit price respectively for each of the particular pay items listed below and 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 antistripping 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.

2) **Price adjustment.** If the thickness determined as per clause 305.3.2 of this specification is deficient by more than three (3) mm, but not more than ten (10) mm, payment will be made at an adjusted price as specified in table-1 below:-

Table - 1

Deficiency in thickness as determined by cores	Proportional Rate of contract Price allowed
0.0 mm to 3.0 mm	100%
3.1 mm to 50.0 mm	90%
5.1 mm to 10.0 mm	80%

When wearing course is more than ten (10) mm deficient in thickness, the contractor shall remove such deficient areas and replace them with wearing course of an approved quality and thickness or the contractor may opt to place an additional layer of wearing course asphalt, grading with a minimum thickness of 35 mm. The contractor will receive no compensation for the above additional work.

Alternately, the Contractor may choose to overlay the area in a thickness of 30 mm (min.) with smooth transition as approved by the Engineer on either side with no extra compensation.

Pay Item No.	Description	Unit of Measurement
305a	Asphaltic Concrete for Wearing Course (Class A)	CM
305 b	Asphaltic Concrete for Wearing Course (Class B)	CM

ITEM 401 CONCRETE

401.1 DESCRIPTION

This work consists of furnishing placing, curing, finishing including transport of cement concrete made from approved type of Cement, water, fine and coarse aggregates all in accordance with the requirements in these specifications and conforming to the lines, grades, and typical sections shown on the Drawings or called for in the special Provisions and to the approval of the Engineer.

401.1.1 Classes of Concrete

The classes of concrete recognized in these specifications shall be designated: A,13,QD1,D2,D3,Y and Lean Concrete. The Class of concrete to be used shall be as called for on the Drawings or as directed by the Engineer or specified in the Special Provisions. The following requirements shall govern unless otherwise shown on the Drawings.

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

Class B Concrete shall be used only where specified.

Class C Concrete shall be used for cribbing, or as otherwise directed by the Engineer or specified in the Special Provisions or on the Drawings.

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

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

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

The concrete of the various classes shall satisfy the requirements shown in Table 401 –1

Table 401-1
Portland Cement Concrete Requirements

Class of Concrete	Min. Cement Kg / Cubic Meter	Maximum Size of Coarse Aggregate (mm)	28 Days Compressive Strength (Min.) (Cylinder) (Kg / Sq.cm)	Consistency (Range in Slump) Vibrated (mm)	Maximum Permissible Water – Cement Ratio
A_1	300	20	210	25 – 75	0.58
A_2	350	25	245	100 – 150	0.58
A_3	400	38	280	100 – 150	0.58
B	250	51	170	25 – 75	0.65
C	275	38	210	25 – 75	0.58
D_1	450	25	350	50 – 100	0.40
D_2	500	25	425	50 – 100	0.40
D_3	550	25	500	50 – 100	0.40
Y	400	13	210	25 – 75	0.58
Lean Concrete	175	51	100	–	–

401.1.2 TYPES OF CONCRETE WORKS

Under Ground Concrete

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

On Ground Concrete

Concrete poured by erecting formwork with necessary bracings on ground.

Elevated Concrete

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

401.2 MATERIAL REQUIREMENTS

401.2.1 Portland Cement

Cement remaining in bulk storage at the mill, prior to shipment, for more than six (6) months or cement stored in local storage by contractor for more than three (3) months after shipment from the factory may be retested before use and shall be rejected if it fails to meet any of the specification requirements.

Portland cement shall conform to the requirements of the Standard Specifications for Portland cement, AASHTO Designation M85 (ASTM Designation C150). The type of the cement to be used, unless otherwise shown on the Drawings, shall be type 1.

Sampling of cement shall be in accordance with AASHTO Designation T-127.

Mill certificates shall accompany delivery of the material to the work.

Cement shall be delivered in sufficient quantities to ensure that there is no suspension of the work of concreting at any time. Different brand or different types of cement from the same mill, or the same brand or type from different mills shall not be mixed or used alternately in the same item of construction unless authorized by the Engineer, after preparing new mix design.

401.2.2 **Fine Aggregate**

The fine aggregate shall consist of sand, stone screenings or other approved inert materials with similar characteristics, or a combination thereof, having clean, hard, strong, sound, durable, uncoated grains free from injurious amount of dust, lumps, soft or flaky particles, shale alkali, organic matter, material reactive with alkalis in the cement loam or other deleterious substances, and shall not contain more than three (3) percent of material passing the No.200 sieve by washing nor more than one percent of clay lumps or one (1) percent of shale. The use of beach sand is prohibited without the written consent of the Engineer.

For exposed work, the fine aggregate shall be free from any substance that will discolour the concrete surface.

The fine aggregate shall be uniformly graded and when tested in accordance with AASHTO Designation T-1 1 and T-27 shall meet the following grading requirements:

GRADING OF FINE AGGREGATES

3/8”	100
No. 4	95 – 100
No. 16	45 – 85
No. 50	10 – 30
No. 100	2 – 10
No. 200	0 – 3

In case if fine aggregates fail under Fineness Modulus or Gradation however material passing No. 4 in combined aggregate, qualifies for these requirements, then the material can be accepted.

Fine aggregates shall be of such quality that mortar specimens, prepared with standard Portland cement and tested in accordance with AASHTO Designation T-71, shall develop a compressive strength at 7 days of not less than 90 percent of the strength developed by a mortar prepared in the same manner with the same cement and graded sand having a fineness modulus of 2.3 to 3. 1. Natural aggregates if required shall be thoroughly and uniformly washed before use. Sand equivalent (T-176) shall be 75 min.

For the purpose of determining the degree of uniformity, a fineness modulus determination shall be made upon representative samples submitted by the Contractor from such sources as he proposes to use. Fine aggregate from any one source having a variation in fineness modulus of greater than 0.20 either way from the fineness modulus of mix design samples submitted by the Contractor may be rejected till new trial mixes are prepared and tested by the contractor.

Testing of the aggregate is specified under Item 401.3.9 of these specifications.

401.2.3 **Coarse Aggregate**

The coarse aggregate shall consist of crushed or broken stone, gravel or other approved inert materials with similar characteristics, or a combination thereof, having clean, hard, strong, sound, durable uncoated particles, free from injurious amount of soft, friable, thin elongated, or laminated pieces, alkali, organic or other deleterious matter and conforming to the requirements of these Specifications.

The coarse aggregate shall be of uniform grading with maximum sizes as required for the various classes of concrete as shown in Table 401-2 and when tested in accordance with AASHTO Designation T-11 & T-27 shall meet the following grading requirements.

TABLE 401.2
GRADING OF COARSE AGGREGATES

Designated Sizes	Percentage by Weight Passing Laboratory Sieves Having Square Openings, in Inches							
½" to No. 4	-	-	-	-	100	90-100	40-70	0-15*
¾" to No. 4	-	-	-	100	90-100	-	20-55	0-10*
1" to No. 4	-	-	100	95-100	-	25-60	-	0-10*
1½" to No. 4	-	100	95-100	-	35-70	-	10-30	0-5
2" to No. 4	100	95-100	-	35-70	-	10-30	-	0-5
1½" to ¾"	-	100	90-100	20-55	0-15	-	0-5	-
2" to 1"	100	90-100	35-70	0-15	-	0-5	-	-

*Not more than five 5 percent shall pass No.8 sieve.

Coarse aggregate shall contain not more than one (1) percent by weight of material passing the No.200 sieve by washing and not more than five (5) percent of soft fragments.

It shall have an abrasion loss of not more than forty (40) percent at five hundred (500) revolutions, when tested in accordance with AASHTO T-96.

When tested in accordance with AASHTO TA 04, for five cycle, the loss with the sodium sulphate soundness test shall be not more than 12 percent.

Natural aggregates shall be thoroughly washed before use. Testing of coarse aggregate is specified under Item 401.3.9 of these Specifications.

The aggregate shall be non-alkali / silica reactive where the concrete is to be poured under water or exposed to humid conditions. In case the Contractor proposes to use the aggregate having the alkaline / siliceous characteristics with the intention to use it with Blast Furnace Slag Cement, he will under take to carry out the job with out any extra cost and shall arrange to conduct the necessary tests as directed by the Engineer.

401.2.4 **Combined Aggregate**

The coarse and fine aggregate shall be combined in the proportions according to the approved trial mixes for each class of concrete.

401.2.5 **Rubble or Cyclopean Concrete**

Rubble or cyclopean concrete shall consist of tough, sound, and durable rock. The stone shall be free from coatings, seams, or flaws of any character. In general, the percentage of wear shall not exceed fifty (50) when tested in accordance with the Standard Method of Testing for Abrasion of Coarse Aggregate by the use of the "Los Angeles Machine", ASTM C535.

401.2.6 **Storage of Cement and Aggregates**

a) All cement shall be stored, immediately upon arrival on the site of the work, in weather-proof building, which will protect the cement from dampness. The floor shall be raised from the ground. The buildings shall be placed in locations approved by the Engineer. Provisions for storage shall be ample, and the shipments of cement as received shall be separately stored in such a manner as to provide easy access for identification and inspection of each shipment. Storage buildings shall have capacity of a sufficient quantity of cement for at least thirty (30) days use. Bulk cement, if used, shall be transferred to elevated air tight and weather-proof bins. However, if approved, sacked cement on small jobs may be stored in the open, upon a raised platform provided that ample waterproof covering is ensured. Stored cement shall meet the test requirements at any time after storage when the Engineer orders retest. At the time of use all cement shall be free flowing and free of lumps. Cement bags shall be weighed at random to cheek for variation.

Copies of cement records shall be furnished to the Engineer showing such detail as, the quantity used during the day run or at each part of the work Cement held in storage for a period of over sixty (60) days, or cement, which, for any reason the Engineer may suspect of being damaged, shall be subject to a retest before being used in the work.

b) The handling and storing of concrete aggregates shall be such as U prevent segregation or the inclusion of foreign materials. The Engineer ma,, require that aggregates be stored on separate platforms at satisfactory, locations.

In order to secure greater uniformity of the concrete mix, the Engineer ma require that the coarse aggregate be separated into two or more size Different sizes of aggregate shall be stored in separate bins or in separate stock piles to prevent the material at the edges of the piles from becoming intermixed.

If aggregates are stored on the ground the bottom layer of aggregate shall not be disturbed or used without reclining and as approved by the Engineer.

401.2.7 **Water**

The water for curing, for washing aggregates and for mixing shall be subject to the approval of the Engineer. It shall be free from oil and shall contain not more than one thousand (1,000) parts per million of chlorides nor more than one thousand three hundreds (1,300) parts per million of sulphates (S04). In no case shall the water contain an amount of impurities that will cause a change in the setting time of Portland cement of more than twenty five (25) percent nor a reduction in the compressive strength of mortar at fourteen (14) days of more than five (5) percent when compared to the result obtained with distilled water.

In non-reinforced concrete work, the water for curing, for washing aggregates, and for mixing shall be free from oil and shall not contain more than two thousands (2,000) parts per million of chlorides nor more than one thousand five hundreds (1,500) parts per million of sulphates as S04.

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

When required by the Engineer, the quality of the mixing water shall be determined by the Standard Method of Test for Quality of Water to be used in concrete, AASHTO Methods of Sampling and Testing, Designation: T 26.

401.2.8 **Admixtures**

Admixtures shall only be allowed to be used with written permission from the Engineer. If air-entraining agents, water reducing agents, set retarders or strength accelerators are permitted to be used, they shall not be used in greater dosages than those recommended by the manufacturer, or permitted by the Engineer, and shall conform to the requirements for each of the agents specified by the manufacturer.

401.3 **CONSTRUCTIONREQUIREMENTS**

The manufacturing, transport, handling and placing of concrete shall conform with the requirements given hereinafter.

Unless otherwise specified, ordinary Portland cement shall be used for all types of concrete. When sulphate resisting cement or other type of cement is required, it will be specified on the Drawings/or in BOQ or ordered by the Engineer.

401.3.1 **Proportioning of Concrete**

All. Weighing shall proportion concrete, except as specified herein. The proportions by weight of cement, fine aggregates, coarse aggregates and water necessary to produce concrete of the required strength and the Engineer shall approve consistency. Such approval may be withdrawn at any time, and changes in the proportions may be required for the purpose of required workability, density, impermeability, durability and strength.

Based on the approved mix proportions, the Contractor shall prepare lists showing the number of kilograms of the various material to be used in the batch size adopted. The required consistency shall also be shown. Such lists are subject to approval by the Engineer, and shall be posted at the mixer. The amount of water in the mix is the total amount of free water, including the free water held by the aggregates.

No concrete shall be placed in the works until the results of the twenty eight (28) days test indicate that the design proportions are satisfactory as per requirements under Item 401.3.10 'Testing of Compressive Strength". Adjustment of the proportions shall be subject to the following provisions:

a) Adjustment for variation in workability - If it is found impossible to obtain concrete of the desired workability with the proportions originally approved, the Engineer shall make such changes as are necessary.

b) Adjustment for new materials - No change in the source or character of the material shall be made without due notice to the Engineer and no new materials shall be used until the Engineer has accepted such materials and has approved new proportions based on trial mixes. The Contractor's attention is drawn to the time required to prepare and test trial batches and the Contractor shall be responsible for production of trial batches at a sufficiently early date so that the progress of the work is no delayed.

401.3.2 **Consistency**

Concrete shall have a consistency such that it will be workable in the required position. It shall be of such a consistency that it will flow around reinforcement steel but individual particles of the coarse aggregate when isolated shall show a coating of mortar containing its proportionate amount of sand. The consistency of concrete shall be determined to be as dry as is practicable to satisfy the requirements for transportation and placing the concrete as described hereinafter.

Consistency of concrete shall be determined as specified in AASHTO T-119. The Consistency of concrete at the time of delivery shall be shown in Table 401.1 or as designated by the Engineer.

401.3.3 **Mixing Concrete**

a) **Mixing General**

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

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

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

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

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

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

The accuracy of all weighing devices except that for water shall be such that successive quantities can be measured to within one (1) percent of the desired value. Cement in standard packages (bags) approved by the Engineer need

not be weighed. The water measuring device shall be accurate to plus or minus half percent + 0.50%. All measuring devices shall be subject to the approval of the Engineer' Scales and measuring devices shall be tested at the expense of the Contractor as frequently as the Engineer may deem necessary to ensure their accuracy.

Weighing equipment shall be isolated so that vibration or movement of other operating equipment do not effect the accuracy of reading. When the entire plant is running, the scale reading at cut-off shall not vary from the weight designated by the Engineer more than one (1) percent for cement, one and half (1.112) percent for any size of aggregate, or one (1) percent for the total aggregates in any batch.

Where volumetric measurements are authorized by the Engineer, the weight proportions shall be converted to equivalent volumetric proportions. In such cases, suitable allowances shall be made for variations in the moisture condition of the aggregates, including the bulking effect in the fine aggregates. Boxes or similar containers of the exact volume required shall be filled and struck off. Measurement by wheel barrow volumes will not be permitted.

b) **Mixing at Site**

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

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

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

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

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

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

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

All concrete shall be mixed for a period of not less than one and half (1.1/2) minutes after all materials, including water, are in the mixer. During the period of mixing, the mixer shall operate at the speed for which it has been designed.

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

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

c) **Plant Mixing**

At central mixing plant, batches shall be discharged from the weighing hopper into the mixer either directly by gravity or by an elevating container large enough to contain the batch. The plant shall be arranged to ensure that there is no loss of

cement during transfer from weighing hopper to the mixer drum. The mixing time shall neither be less than fifty (50) second, nor more than ninety (90) seconds.
The plastisizer, accelerator or retarder or water-reducing admixture, if required, shall be fed separately at the rate recommended by the manufacture, or as established by laboratory trials.

d) **Transit Mixing**

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

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

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

e) **Partial Mixing at the Central Plant**

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

f) **Stiff Concrete Mix**

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

g) **Hand Mixing**

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

401.3.4 Hauling and Delivery of Mixed Concrete

a) **Hauling**

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

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

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

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

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

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

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

a time less than one hour will be required except when retarder is used in which case it shall be one (1) hour.

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

b) **Delivery**

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

e) Retempering

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

401.3.5 <u>Handling and Placing Concrete</u>

a) General

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

No concrete shall be used that does not reach its final position in the forms within the time stipulated above under Item 401.3.4 "Hauling and Delivery of Mixed Concrete".

Concrete shall be placed so as to avoid segregation of the materials and the displacement of the reinforcement. The

use of long troughs, chutes, and pipes for conveying concrete to the forms shall be permitted only on written authorization of the Engineer. In any case the Engineer will reject the use of equipment for concrete transportation that will allow segregation, loss of fines, or in any other way will have a deteriorating effect on the concrete quality.

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

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

When placing operations would involve dropping the concrete more than one and half (1.1/2) meters, it shall be conveyed through sheet metal or other approved pipes. As far as practicable, the pipe shall be kept buried in the newly placed concrete. After initial set of the concrete the forms shall not be jarred and no loading of any kind shall be placed on the ends of projecting reinforcement bars.

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

b) Pneumatic Placing

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

Where concrete is conveyed and placed by pneumatic means, the equipment shall be suitable in kind and adequate in capacity for the work. The machine shall be located as close as practicable to the work. The discharge lines shall be horizontal or inclined upwards from the machine.

At the conclusion of placing the concrete, the entire equipment shall be thoroughly cleaned.

c) Pumping

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

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

d) Placing Concrete Under Water

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

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

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

A tremie shall consist of a tube having a diameter of not less than 25 cm constructed in sections having flanged couplings fitted with gaskets with a hopper at the top. The tremie shall be supported so as to permit free movement of the discharge end over the entire top surface of the work and so as to permit rapid lowering when necessary to retard or stop the flow of concrete. The discharge end shall be closed at the start of work so as to prevent water entering the tube and shall be completely submerged in concrete at all times; the tremie tube shall be kept full to the bottom of the hopper. When a batch is dumped into the hopper, the flow of concrete shall be induced by slightly raising the discharge end, but always keeping it in the placed concrete. The flow shall be continuous until the work is completed.

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

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

e) Compaction

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

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

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

401.3.6 **Casting Sections and Construction Joints**

a) General

The concrete in each integral part of a structure shall be placed continuously, and the Contractor will not be allowed to commence work on any such part unless sufficiently inspected and approved material for the concrete is at hand, and manpower and equipment are sufficient to complete the part without interruption in the placing of the concrete.

Construction joints shall be allowed only where specified on the plans or otherwise approved. If not detailed on the plans, or in the case of emergency, construction joints shall be placed as directed. Shear keys or inclined reinforcement shall be used where necessary to transmit shear or bond the two sections together. When shear keys or inclined reinforcement are not provided, the concrete shall be roughened as directed. Joints in the concrete due to discontinuity of work shall be avoided as far as possible. Such joints, when necessary, shall, be constructed to meet the approval of the Engineer.

When the placing of concrete is temporarily discontinued, the concrete after becoming firm enough to retain its shape, shall be cleaned of laitance and other objectionable material to a sufficient depth to expose sound concrete. Where a 1eathered edge" might be produced at a construction joint, as in the sloped top surface of a wing wall, an inset formwork shall be used to produce an edge thickness of not less than 15 centimetres in the succeeding layer. Work shall not be discontinued within fifty (50) centimetres of the top of any face, unless provision has been made for a coping less than 50 centimetres thick, in which case, if permitted by the Engineer, the construction joint may be made at the underside of coping.

Immediately following the discontinuance of placing concrete all accumulations of mortar splashed upon the reinforcing steel and the surfaces of forms shall be removed. Dried mortar chips and dust shall not be puddled into the unset concrete. Care shall be exercised, during the cleaning of the reinforcing steel, not to injure or break the concrete steel bond near the surface of the concrete.

b) Slab Culverts

In general, the lean concrete below the foundation shall be placed and allowed to set before the reinforced concrete is started.

After the construction of masonry abutment walls, as specified in Special Provisions, the concrete bed plate and

curtain walls shall be constructed monolithically. Construction joints in wing walls where unavoidable shall be horizontal and so located that no joint will be visible in the exposed face of the wing wall above the ground line.

c) Box Culverts

Vertical construction joints shall be at right angles to the axis of the culvert.

In general, the base slab or footings of box culverts shall be placed and allowed to set before the remainder of the culvert is constructed. In this case, suitable *provision shall be made for bonding the sidewalls to the culvert base, preferably by means of raised longitudinal keys so constructed as to prevent, as far as possible, the percolation of water through the construction joint.

In the construction of box culverts one and quarter (1.114) meters or less in height, the sidewalls and top slab may be constructed as a monolithic unit. When this method of construction is used, necessary construction joints shall be vertical and at right angles to the axis of the culvert.

In the construction of box culverts more than one and quarter (1.114) meters in height the concrete in the walls shall be placed and allowed to set before the top slab is placed. In this case, appropriate keys shall be left in the sidewalls for anchoring the cover slab.

If possible, each wingwall shall be constructed as a monolithic unit. Construction joints, where unavoidable, shall be horizontal and so located that no joint will be visible in the exposed face of the wingwall above the ground line.

d) Girders, Slabs and Columns

For simple spans, concrete shall preferably be deposited by beginning at the center of the span and working from the center toward the ends. Concrete in girders shall be deposited uniformly for the full length of the girder and brought up evenly in horizontal layers. For continuous spans, where required by design considerations, the concrete placing sequence shall be shown on the plans or in the Special Provisions.

Concrete in girder haunches less than one (1) meter in height shall be placed at the same time as that in the girder stem, and the column or abutment tops shall be cut back to form seats for the haunches. Whenever any haunch or fillet has a vertical height of one (1) meter or more, the abutment or columns, the haunch; and the girder shall be placed in three successive stages; first, to. lower side of haunch;

second, to the lower side of the girder; and third to completion.

For haunched continuous girders, the girder stem (including haunch) shall be placed to the top of stem. Where the size of the pour is such that it cannot be made in one continuous operation, vertical construction joints shall preferably be located within the area of contraflexure.

Concrete in slab spans shall be placed in one continuous operation for each span unless otherwise provided. The floors and girders of through girder superstructures shall be placed in one continuous operation unless otherwise specified, in which case a special shear anchorage shall be provided to ensure monolithic action between girder and floor.

Concrete in T-beam or deck girder spans may be placed on one continuous operation or may be placed in two separate operations; each of which shall be continuous; first, to, the top' of the girder stems and second, to completion. In the latter case, the bond between stem and slab shall be provided by suitable shear keys or by artificially roughening the surface of the top of the girder stem. In general, suitable keys may be formed by the use of timber blocks approximately five (5) by ten (10) cm in cross-section and having a length of ten (10) cms less than the width of the girder stem. These key blocks shall be spaced along the girder stems as required, but the spacing shall be not greater than thirty (30) cms center to center. The blocks shall be removed as soon as the concrete has set sufficient to retain its shape.

Concrete in box girders may be placed in two or three separate operations. In either case the bottom slab shall be placed first. Bond between the bottom slab and stem shall be positive and mechanical. If the webs are placed separately from the top slab, bond between the top slab and webs shall be secured in the same manner as for T-beams. Requirements for shear keys for T-beams shall also apply to box girders, except that keys need not be deeper than the depth to the top of bottom slab reinforcement.

Concrete in columns shall be placed in one continuous operation, unless otherwise directed. The concrete shall be allowed to set at least 24 hours before the caps are placed.

When friction collars are used to support cap forms, the concrete of columns shall have been poured at least seven (7) days earlier.

Unless otherwise permitted, no concrete shall be placed in the superstructure until the column forms have been stripped

sufficiently to determine the character of the concrete in the columns. The load of the superstructure shall not be allowed to come upon the bents until the test cylinders representing the bents have obtained the minimum compressive strength but in no case in less than seven (7) days.

e) Construction Joints

Construction joints shall be made only where shown on the Drawings or called for in the pouring schedule, unless otherwise approved by the Engineer. If not detailed on the Drawings, construction joints, also in cases of emergency shall be placed to meet the approval of the Engineer. Shear keys or reinforcement shall be used, unless otherwise specified, to transmit shear or to bond the two sections together.

Before depositing new concrete on or against concrete, which has hardened, the forms shall be re-tightened. The surface of the hardened concrete shall be roughened as required by the Engineer, in a manner that will not leave loose particles of aggregate or damage concrete at the surface.' It shall be thoroughly cleaned of foreign matter and laitance. When directed by the Engineer, the surface of the hardened concrete which will be in contact with new concrete shall be washed with water to ensure an excess of mortar at the juncture of the hardened and the newly deposited concrete, the cleaned and watered surfaces, including vertical and inclined surface, shall first be thoroughly covered with a coating of mortar of the same proportion of sand and cement as the class of concrete used against which the new concrete shall be placed before the grout or mortar has attained its final set.

The placing of concrete shall be carried out continuously from joint to joint. The face edges of all joints, which are exposed, to view shall be carefully finished true to line and elevation.

f) Rubble or Cyclopean Concrete

Rubble or cyclopean concrete shall consist of Class B concrete containing large embedded stones. The stone for this class of work shall be placed carefully so as to avoid damage to the forms or to the partially set adjacent concrete. Stratified stone shall be placed upon its natural bed. Stone shall be washed and saturated with water before placing.

The total volume of the stone shall not be greater than one third of the total volume of the portion of the work in which it is placed. For walls of piers greater than sixty (60) cms in thickness, stone of such size that one man can handle it, shall be used. Each stone shall be surrounded by at least

fifteen (15) cms of concrete and no stone shall be closer than thirty (30) cms to any top surface nor any closer than fifteen (15) cms to any coping. For walls or piers greater than one (1) meter in thickness, larger stone (50 Kg or more) may be used. Each stone shall be surrounded by at least thirty (30) cms of concrete, and no stone shall be closer than sixty (60) cms to any top surface nor closer than twenty (20) cms to any coping.

g) Concrete Exposed to Sea Water

Unless otherwise specifically provided, concrete for structures exposed to seawater shall be Class A. The clear distance from the face of the concrete to the nearest face of reinforcement steel shall be not less than 10 cms. The concrete shall be mixed for a period of not less than 2 minutes and the water content of the mixture shall be carefully controlled and regulated so as to produce concrete of maximum impermeability. The concrete shall be thoroughly compacted and air pockets shall be avoided. No construction joints shall be formed between levels of extreme low water and extreme high water as determined by the Engineer. Between these levels sea water shall not come in contact with the concrete for a period of not less than thirty (30) days. The original surface, as the concrete comes from the forms, shall be left undisturbed.

h) Concrete Exposed to Alkali Soils or Alkali Water

Where Concrete may be exposed to the action of alkaline water or soils, special care shall be taken to place it in accordance with specifications herein. Wherever possible, placing shall be continuous until completion of the section or until the concrete is at least fifty (50) cms, above ground or water level. Alkaline water or soils shall not be in contact with the concrete during placement and for a period of at least seventy two (72) hours thereafter.

i) Protection of Concrete from Environmental Conditions

i. General

Precautions shall be taken as needed to protect concrete from damage due to weather or other environmental conditions during placing and curing operations.

Any concrete placed during hot weather or during cold weather shall be at the Contractor's risk and any damaged concrete shall be removed and replaced at the Contractor's expense.

ii. Rain Protection

Under conditions of rain, the placing of concrete shall not commerce or shall be stopped unless adequate protection is provided to prevent damage to the surface mortar or damaging flow or wash of the concrete surface.

iii. Work in Hot Weather

The temperature of concrete shall not exceed thirty two (32) degree C at the time of laying, unless the Contractor incorporates in the mix a plasticiser, of a make and in proportion which he has shown by laboratory tests and full scale trial to be satisfactory, to eliminate detrimental effects of high temperature without introducing any other detrimental effect on quality.

The following may be used to keep the temperature of concrete below the above limitations:

i) Chilling of concrete water by heat exchange coils or by addition of broken ice, provided that the water shall be free from ice at the time of entry into the mixer.

ii) Cooling of coarse aggregate by watering, provided that the water content of the aggregate so cooled shall be uniform.

iii) Reclaiming of aggregate from stock piles by the tunnel method to avoid using the surface layer of the stockpile with shade and wind protection of conveyor elevating to batching plant.

iv) Night work provided that (i), (ii) and (iii) are proved inadequate or unsatisfactory in their results and providing also that the Engineer has no other reason for refusing permission for night work.

The Engineer shall have power to order the suspension of concrete production in case of not taking precautionary measures by the Contractor as mentioned above. Under no circumstances will the Contractor be entitled to receive any additional payment for complying with the requirements of this clause.

iv. Work in Cold Weather

Except by written approval of the Engineer, concreting operations shall not be continued when a descending air temperature in the shade and away from artificial heat fails below five (6) degree C, nor resumed until an ascending air temperature in the shade and away from artificial heat reaches two (2) degree C. In such cases, the mixing water and / or aggregates shall be heated to not less than twenty one (21) degree C nor more than sixty six (66) degree C, prior to being placed in the mixer by an approved type of heating device so that the temperature of the concrete shall not be less than ten (10) degree C, nor more than twenty seven (27) degree C, at the time of placing. No materials containing frost shall be used. Cement or fine aggregates containing lumps or crusts of hardened materials shall not be used.

401.3.7 Concrete Surface Finishing / Rendering

a) General

Concrete surface finishes shall be classified as follows:

i. Bridge Deck Surface Finish
ii. Sidewalk Surface Finish
iii. Ordinary Surface Form Finish
iv. Class 1 Surface Form Finish

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

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

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

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

b) Bridge Deck Surface Finish

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

the requirements specified herein for finishing bridge roadway deck concrete.

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

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

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

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

Rails for the support and operation of finishing machines and headers for hand-operated stick-off devices shall be completely in place and firmly secured for the scheduled length for concrete placement before placing of concrete. Rails for finishing machines shall extend beyond both ends of the scheduled length for concrete placement to a sufficient distance that will permit the float of the finishing machine to fully clear the concrete to be placed. Rails or headers shall be adjustable for elevation and shall be set to elevations, with allowance for anticipated settlement, camber, and deflection of false work, as required to obtain a bridge roadway deck true to the required grade and cross-section. Rails or headers shall be of a type and shall be so installed that no springing or deflection will occur under the weight of the finishing equipment and shall be so located that finishing equipment may operate without interruption over the entire bridge roadway deck to be finished.

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

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

Unless otherwise permitted by the Engineer, bridge deck concrete shall be placed in a uniform heading approximately parallel to the bridge pier or bent caps. The rate of placing concrete shall be limited to that which can be finished before the beginning of initial set except that concrete for the deck surface shall not be placed more than three (3) meters ahead of strick off.

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

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

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

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

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

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

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

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

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

Immediate following completion of the deck finishing operations, the concrete in the deck shall be cured as specified in Item 401.3.8 "Curing Concrete" hereinafter.

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

Where the concrete of the bridge deck is to be covered by bituminous surfacing, earth, or other cover, two and half 2.5 cms or more in thickness, the surface of the concrete shall not vary more than nine (9) mm from the lower edge of the three (3) meter straightedge.

Bridge deck surfaces under the curbs, railings and sidewalk shall be struck off to the same plane as the roadway and left undisturbed when future widening is shown on the plans.

c) Sidewalk Surface Finish

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

d) Ordinary Surface Form Finish

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

Except as provided herein, all form bolts and any metal placed for-the convenience of the Contractor shall be removed to a depth of at least two and half (2.5) cms below the surface of the concrete. All rock pockets and other unsound concrete shall be removed. The resulting holes or depression shall be cleaned and filled with mortar. Form bolts projecting into the cells of box girders need not be removed unless permanent access is provided into the cells,

in which case such bolts shall be removed flush with the surface of the concrete. Mortar used to fill bolt holes shall consist of one part cement and two parts sand. Other depressions and pockets shall be filled with either packed mortar or air blown mortar as directed by the Engineer. Mortar shall be cured in conformance with the requirements in Item 401.3.8 (c) "Curing Structures".

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

e) Class 1 Surface Form Finish

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

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

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

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

i) All form finish surfaces of bridge super-structures, except the under surfaces between girders and the inside vertical surfaces of T girders.

ii) All surfaces of bridge piers, columns and abutments, and retaining walls above finished ground and to at least three tenth (0.3) meter below finished ground.

iii) All surfaces of open spandrel arch rings, spandrel columns and abutment walls.

iv) All surfaces of pedestrian undercrossings, except floors and surfaces to be covered with earth.

v) Surface above finished ground of culvert headwalls, endwails and retaining wails.

vi) Surface inside of culvert barrels having a height of one and half (1.5) meters or more for a distance inside the barrel at least equal to the height of the culvert.

vii) All surfaces of railings.

f) Surface Rendering

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

401.3.8 Curing Concrete

a) General

All newly placed concrete shall be cured in accordance with these specifications, unless otherwise directed by the Engineer.

b) Method of Curing

The curing method shall be one or more of the following as described hereinafter.

i. Water Method
ii. Curing compound Method
iii. Reinforced Waterproof Paper Method if required by the Engineer.
iv. Forms-in-Place Method Steam Method Polyethylene Sheeting Method

Water Method

The concrete shall be kept continuously wet by the application of water for a minimum period of seven (7) days after the concrete has been placed.

Cotton mats, burlaps, rugs, carpets, or earth or sand blankets, may be used as a curing medium to retain the moisture, the entire surface of the concrete shall be kept damp by applying water with a nozzle that so atomized the flow that a mist and not a spray is formed, until the surface of the concrete is covered with the curing medium. The

moisture from the nozzle shall not be applied under pressure directly upon the concrete in a quantity sufficient to cause a flow or wash the surface. At the expiration of the curing period the concrete surface shall be cleared of all curing mediums.

When concrete bridge decks and flat slabs are to be cured without the use of a moisture retaining medium, the entire surface of the bridge deck or slab shall be kept damp by the application of water with an atomizing nozzle as specified in the preceding paragraph until the concrete has set, after which the entire surface of the concrete shall be sprinkled continuously with water for a period of not less than seven (7) days.

Curing Compound Method

Surfaces exposed to the air may be cured by the application of an impervious membrane if approved by the Engineer.

The membrane-forming compound used shall consist of a practically colourless liquid. The use of any membrane forming compound that will alter the natural colour of the concrete or impart a slippery surface to any wearing surface shall be prohibited. The compound shall be applied with a pressure spray in such a manner as to cover the entire concrete surface with a uniform film, and shall be of such character that it will harden within 30 minutes after application. The amount of compound applied shall be ample to seal the surface of the concrete thoroughly. Power operated spraying equipment shall be equipped with an operational pressure gauge and means of controlling the pressure.

The curing compound shall be applied to the concrete following the surface finishing operation immediately after the moisture sheen begins to disappear from the surface, but before any drying shrinkage or craze cracks begin to appear. In the event of any delay in the application of curing compound, which results in any drying or cracking of the surface, application of water with an atomizing nozzle as specified under "Water Method", shall be started immediately and shall be continued until application of the compound which shall not be applied over any free standing water surface. Should the film of compound be damaged from any cause before the expiration of seven (7) days after the concrete is placed in the case of structures, the damaged portion shall be repaired immediately with additional compound.

Curing compounds shall not hard settle in storage. They shall not be diluted or altered in any manner after manufacture. At the time of use, the compound shall be in a thoroughly mixed

condition. If the compound has not been used within one hundred twenty (120) days after the date of manufacture, the Engineer may require additional testing before use to determine compliance to requirements.

An anti-settling agent or combination of anti-settling agents shall be incorporated in the curing compound to prevent caking.

The curing compound shall be packaged in clean barrels or steel containers or shall be supplied from a suitable storage tank located at the job-site. Onsite storage tanks shall have a permanent system designed to completely re-disperse any settled material without introducing air or any other foreign substance. Containers shall be well sealed with ring seals and lug type crimp lids. The linings of the containers shall be of a character that will resist the solvent of the curing compound. Each container shall be labelled with the manufacturer's name, specification number, batch number, number of gallons, and date of manufacture, and shall have a label warning concerning flammability. The label shall also warn that the curing compound shall be well stirred before use. When the curing compound is shipped in tanks or tank trucks, a shipping invoice shall accompany each load. The invoice shall contain the same information as that required*herein for container labels.

Curing compound may be sampled by the Engineer at the source of supply and at the job-site.

Reinforced Waterproof Paper Method

The exposed finished surfaces of concrete shall be sprayed with water, using a nozzle that so atomizes the flow that a mist and not a spray is formed, until the concrete has set, after which the waterproof paper shall be placed. The paper shall remain in place for a period of not less than 72 hours.

Reinforced waterproof paper shall comply with ASTM C 171 specifications. It shall be composed of two sheets of Kraft paper cemented together with a bituminous adhesive and reinforced with fibre. The waterproof paper shall be formed into sheets of such width as to provide a complete cover of entire concrete surface.

All joints in the sheets shall be securely cemented together in such a manner as to provide a waterproof joint. The joint seams shall have minimum lap of ten (10) cm.

The sheets shall be securely weighted down by placing a bank of earth on the edges of the sheets or by other means satisfactory to the Engineer.

Should any portion of the sheets be broken or damaged within seventy two (72) hours after being placed, the broken or damaged portions shall be immediately repaired with new sheets properly cemented into place.

Sections of sheets, which have lost their waterproof qualities or have been damaged to such an extent as to render them unfit for curing the concrete shall not be used

Forms-in-Place Method

Formed surfaces of concrete may be cured by retaining the forms-in-place. The forms shall remain in place for a minimum period of seven (7) days after the concrete has been placed, except that for members over five (5) cms in least dimension, the forms shall be in place for a minimum period of five (5) days. Wooden forms shall be kept wet by watering during the curing period.

Steam Method

After placing and vibrating, the concrete shall be allowed to attain its initial set before steam is applied. During the placing of concrete and application of steam, provision shall be made to prevent surface drying by means of a coating of approved material. The optimum curing temperature shall not exceed sixty five (65) degree C.

Polyethylene Sheeting Method

The wet surface of fresh concrete shall be covered with white polyethylene sheeting as soon as possible without marring the surface and should cover all exposed surfaces of the concrete. The edges of the sheeting shall be weighted securely with a continuous windrow of earth or any other means satisfactory to the Engineer to provide an air-tight cover. Adjoining sheets shall overlap not less than thirty (30) cms. and the laps shall be securely weighted with earth, or any other means satisfactory to the Engineer to provide an airtight cover.

c) **Curing Structures**

All newly placed concrete for cast-in-place structures, other than highway bridge decks, shall be cured by the water method, the forms-in-place method, or, as permitted herein, by the curing compound method, ail in accordance with the requirements in Item 401.3.8 (b), Methods of Curing".

The curing compound method may be used on concrete surfaces, which are to be buried, underground, and surfaces where only Ordinary Surface Finish is to be applied and on which a uniform colour is not required and which will not be visible from any public travelled way.

The top surface of highway bridge decks shall be cured by both the curing compound method, and by the water method. The curing compound shall be applied progressively during the deck finishing operation immediately after finishing operations are completed on each individual portion of the deck. The water cure shall be applied not later than four (4) hours after completion of the deck finishing or, for portions of the decks on which finishing is completed after normal working hours, the water cure be applied not later than 8.00 a.m. the following morning.

When deemed necessary by the Engineer during periods of hot weather, water shall be applied to concrete surfaces being cured by the curing compound method or by the forms-in-place method, until the Engineer determines that a cooling effect is no longer required.

d) **Curing Precast Concrete Members**

Precast concrete members shall be cured for not less than seven (7) days by the water method or by steam curing for a period in which 80% of strength achieved, at the option of the Contractor. Steam curing for precast members shall conform to the following provisions:

After placement of the concrete, members shall be held for a minimum four (4) hours precasting period.

To prevent moisture loss on exposed surfaces during the presteaming period, members shall be covered immediately after casting or the exposed surfaces shall be kept wet by fog spray or wet blankets.

Enclosures for steam curing shall allow free circulation of steam about the member and shall be constructed to contain the live steam with a minimum moisture loss. The use of the tarpaulins or similar flexible covers will be permitted, provided they are kept in good repair and secured in such a manner to prevent the loss of steam and moisture.

Steam at jets shall be low pressure and in a saturated condition. Steam at jets shall not impinge directly on the concrete, test cylinders, or forms. During application of the steam, the temperature rise within the enclosure shall not exceed twenty (20) degree C per hour. The curing temperature throughout the enclosure shall not exceed sixty five (65) degree C and shall be maintained at a constant level for a sufficient time necessary to develop the required compressive strength. Control cylinders shall be covered to prevent moisture loss and shall be placed in a location where temperature is representative of the average temperature of the enclosure.

Temperature recording devices that will provide an accurate continuous permanent record of the curing temperature shall be provided. A minimum of one temperature recording device per sixty (60) meters of continuous bed length will be required for checking temperature.

Curing of precast concrete will be considered completed after a termination of the steam curing cycle.

e) Curing Precast Concrete Members

All newly placed concrete precast piles, both conventionally reinforced and prestressed shall be cured by the "Water Method" as described in Item 401.3.8(b) except that the concrete shall be kept under moisture for at least fourteen (14) days. At the option of the Contractor steam curing may be used in which case the steam curing provisions in Item 401.3.8(b) "Curing Precast Concrete Members" shall apply except that the concrete shall be kept wet for at least seven (7) days including the holding and steaming period.

401.3.9 **Testing of Aggregates**

Samples of fine and coarse aggregate to be used shall be selected by the Engineer. It shall be the responsibility of the Contractor to designate the source or sources of aggregate and to obtain the necessary samples and submit them for testing at least thirty (30) days before actual concreting operations are to begin.
Samples of aggregates shall be obtained and tested in accordance with the following standard AASHTO methods:-

i)	Sampling aggregates	T-2
ii)	Sieve analysis	T-27
iii)	Amount of material passing the No.200 sieve.	T-11
iv)	Organic impurities	T-21
v)	Mortar Strength	T-71
vi)	Sodium sulphate soundness	T-104
vii)	Friable particles	T-112
viii)	Abrasion loss	T-96
ix)	Specific Gravity	T-84
x)	Absorption.	T-85
xi)	Production of Plastic Fines.	T-210
xii)	Fineness Modulus	T-27
xiii)	Sand Equivalent	T-17
xiv)	Potential Reactivity of Carbonate Rocks for	
xv)	Concrete Aggregate(Rock Cylinder Method)	ASTM C586
xvi)	Potential Alkali Reactivity of Cement	
	Aggregate Combinations (Morta-Bar Method).	ASTM C227
xvii)	Potential Reactivity of Aggregates	
	(Chemical Methods)	ASTM C289

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

401.3.10 **Testing of Compressive Strength**

Concrete compressive strength requirements consist of a minimum strength at the age of twenty eight (28) days and the minimum strength, which must be attained before various loads or stresses, are applied to the concrete. The various strengths required are specified in Table 401-1.

The compressive strength of concrete will be determined from test cylinders, which have been fabricated from concrete sampled and tested in accordance with AASHTO T 23 and AASHTO T 22.

A set of six (6) cylinders shall be taken from each fifty (50) cubic meters of each class of concrete or fraction thereof placed each day, three (3) of the six (6) cylinders to be tested after seven (7) days and three (3) after twenty eight (28) days.

a) The minimum average 28 days test result of all samples tested at any time shall be the specified twenty eight (28) days strength.

b) No individual samples tested after 28 days shall show a test result lower than eighty five (85) percent of the required twenty eight (28) days.

Concrete represented by any single test cylinders that fails to comply with the requirement under (b) above will be rejected unless the Contractor at his expense, provides evidence that the strength and quality of the concrete placed in the work are acceptable. If such evidence consists of tests made on cores taken from the work, the cores shall be obtained and tested in accordance with the specifications of AASHTO T-24.

Test results of the cores shall meet the following requirements:-

a) Average test result of the cores shall be less than the minimum required twenty eight (28) days strength.

b) No individual core shall show a strength less than Ninety five (95) percent of the required twenty eight (28) days strength.

Should the above test results fail to comply with the requirements, concrete of that particular pour shall be rejected and removed as directed by the Engineer. Further more contractor shall redesign the concrete mix for approval of the Engineer.

In case, seven (7) days strength shows less than seventy (70) percent of the twenty eight (28) days strength (in case of type-1 cement), Engineer may stop further work on that particular portion of concrete, unless twenty eight (28) days strength gives satisfactory results.

Trial Batches for Mix Productions

The placing of concrete shall not begin until trial batches of the mix design to be used have been produced by the Contractor and tested and approved by the Engineer. The trial mix proportions shall be such that the average strength of five (5) consecutive test cylinders shall be 20% higher than the specified twenty eight (28) days strength and no individual test cylinder shall be below the specified strength.

When concrete compressive strength is specified as a prerequisite to applying loads or stresses to a concrete structure or member, test cylinders will be cured under conditions similar to those at the casting site. The compressive strength of concrete determined for such purposes will be evaluated on the basis of individual tests.

401.4 MEASUREMENT AND PAYMENT

401.4.1 Measurement

The quantity of concrete to be paid for shall be the number of cubic meters of concrete of the various classes complete in place and accepted.

In measuring the volume of concrete to be paid for, the dimension to be applied shall be those shown on the Drawings except where others ordered by the Engineer in writing.

Deductions from the theoretical volume of concrete shall be made for the volumes of draining holes, weep holes, pipes and conduits, etc., in case where their cross-sectional areas exceed 500 square centimetres.

The measurement shall not include any concrete used in the construction of cofferdams or falsework.

The volume involved in fillets, scorings, or chamfers ten square centimetres in cross-sectional area or less shall be disregarded when measuring the quantity of concrete to be paid for

Concrete for railings, pipe culverts, etc., is not to be measured under this item, but under separate items.

401.4.2 **Payment**

The accepted quantity measured as provided above shall be paid for at the contract unit price respectively for the pay items listed below that as per shown in the Bill of Quantities which prices and payment shall be full compensation also for such works as curing, surface finishing and / or rendering as required, formation of construction joints and any such work and incidentals necessary to complete the item except works that are paid for under other pay items.

For all concrete structures or portions, thereof, no separate measurement or payment shall be made for false work, centering, formwork or any other temporary work to complete the concrete structure or portion thereof, payment for all such temporary works shall be deemed to be included in the contract price paid under various items of concrete work.

Pay Item No.	Description	Unit of Measurement
401a	Concrete Class:	
	i) Undergrou nd	Cm
	ii) On Ground	Cm
	iii) Elevated	Cm
401b	Concrete Class “B”	Cm
401c	Concrete Class “C”	
	i) Undergrou nd	Cm
	ii) On Ground	Cm
	iii) Elevated	Cm
401d	Concrete Class D_1	Cm
	Concrete Class D_2	Cm
	Concrete Class D_3	Cm
401e	Concrete Class Y	Cm
401f	Lean Concrete	Cm
401g	Precast Concrete, Class …..	Cm

ITEM 501 REINFORCED CONCRETE PIPE CULVERTS

501.1 DESCRIPTION

This work shall consist of the construction, reconstruction or repair of culverts and. water drainage structures in accordance with these specifications, and in conformity with the lines, grades and dimensions shown on the Drawings or ordered by the Engineer.

The work shall include the furnishing and laying of the pipe, and the construction of such joints and connection to other pipes, catch basins, or other structures as may be required to complete the work as shown on the Drawings or as required by the Engineer.

The work shall also include the removal and disposal of existing culverts and structures except such portions as may be required or permitted by the Engineer to be left in place.

The Engineer reserves the right to inspect and test the pipe after its delivery to the work. Injurious defects revealed subsequent to acceptance of pipe and prior to its installation in the work shall be cause for rejection.

The Contractor shall not order and deliver the pipes for any work until the Engineer has approved a list of sizes and lengths.

501.2 MATERIAL REQUIREMENTS

The pipes shall meet the requirements of the AASHTO M-170, class 11 and IV as called for in the Bill of Quantities.

Cement, sand and water shall conform to the requirements specified in item 401 - Concrete, except that the grading of sand shall meet the requirements of AASHTO M-45.

Steel reinforcement shall conform to the requirements specified in Item 404 of these specifications.

Rubber ring gaskets for rigid pipe, if required, shall conform to the requirements of AASHTO M-1 98.

501.3 MANUFACTURING REQUIREMENTS

Reinforced concrete pipe culverts shall conform to the requirements of AASHTO M-170.

501.3.1 **Dimensions and Strength Test Requirements**

Shell thickness, the quantity of circular reinforcement and the strength per linear meter for the various sizes of pipe shall conform to the minimum requirements listed in related Table as per AASHTO MA 70 latest addition.

501.3.2 **Reinforcement**

Each line of reinforcement shall be assembled into a cage, which shall contain sufficient longitudinal bars or members extending through the barrel of the pipe to maintain the reinforcement rigidly in exact shape and correct position within the form. If the splices are not welded, the reinforcement shall be lapped not less than 30 diameters for bars and 40 diameters for cold-drawn wire. If welded, the member at either a welded splice or intersection shall develop a tensile strength of not less than three thousand seven hundred (3,700) Kgf 1 Sq. cm. The spacing centres of adjacent rings of the circumferential reinforcement (pitch) shall not exceed 10 cm. The circumferential reinforcement shall be located midway between the inner and outer surfaces of the pipe within a tolerance of $\pm$ six (6) mm.

501.3.3 **Joints**

The ends of reinforced concrete culvert pipes shall be the ogee or spigot and socket types and of such design that when laid the joints shall form a continuous conduit with a smooth and uniform interior surface.

501.3.4 **Tolerances**

Variations in internal *diameter and wall thickness shall not exceed the limit specified in relevant "Table for Allowable Tolerances" for reinforced concrete pipes in these Specifications.

501.3.5 **Absorption**

The water absorption of the concrete pipe shall not exceed eight (8) per cent of the dry weight as determined in AASHTO designation T-33.

501.3.6 **Curing**

Pipes shall be subjected to any one of the methods of curing described in the following paragraphs or to any other method or combination of methods, approved by the Engineer's Representative, that will give satisfactory results, provided that no pipe shall be used within a period of fourteen (14) days after curing. All pipes shall be marked with the date of casting.

i) Steam Curing

Pipes shall be Placed in a curing chamber, free from outside draughts, and cured in a moist atmosphere, maintained at a temperature between thirty eight (38) and fifty four (54) degree C by the injection of steam for a period of not less than twenty four (24) hours or, when necessary, for such additional time as may be needed to enable the pipe to meet the strength requirements. When a curing chamber is not available, pipes may be placed in an enclosure of canvas or other closely woven material and subjected to saturated steam at the temperature -and for the time specified above. The enclosure shall be so erected as to allow full circulation of steam around the entire pipe. The interior surfaces of the curing room or canvas jackets and the surfaces of the pipes shall be entirely moist at all times.

ii) Water Spray Curing

Under the conditions of enclosure prescribed in (i). above, pipes may be cured by subjecting them to a continuous or frequently applied fine spray of water in an enclosure maintained at a temperature of not less that twenty one (21) degree C for a period of not less than seventy two (72) hours, or such additional time as may be necessary to meet the -strength requirements.

iii) Saturated Cover Curing

The sides and top of each pipe may be covered with heavy Hessian or other suitable material, saturated with water before applying and kept saturated with water at a temperature of not less than twenty one (21) degree C for seventy two (72) hours, or such additional time as may be necessary to meet the strength requirements. The ends of the pipes shall be so enclosed as to prevent the free circulation of air through or around the pipe. If the temperature of the water is less than twenty one (21) degree C, the curing period shall be increased as may be necessary to meet the strength requirements. The ends of the pipes shall be so enclosed as to prevent the free circulation of air through or around the pipe.

501.3.7 Workmanship and Finish

All pipes shall be substantially free from fractures, large or deep cracks, honeycombing, open texture, spells and surface roughness. The planes of the ends of the pipe shall be perpendicular to the longitudinal axis.

501.3.8 **Inspection**

The quality of all materials, the process of manufacture and the finished pipes shall be subject to inspection, test and approval at the place of manufacture. The Contractor shall make the necessary arrangements with the manufacturer to set aside in a separate area all pipes for which he desires approval.

i) Test Specimens

Pipes for the purpose of tests shall be furnished free of cost by the Contractor and will be selected at random by the Engineer. The number of sections required for test will not be more than two (2) percent except that at least one of every size will be selected. Pipes for tests shall conform to these specifications.

ii) Test Equipment

If the manufacturer has equipment for conducting the crushing strength test, the Contractor shall make the necessary arrangements to have the required tests conducted in the presence of the Inspector designated by the Engineer. If the testing facilities are not available at the point of manufacture, the Contractor shall make the necessary arrangements for furnishing & testing, at no cost to the Employer, the pipe sections selected by the Inspector to a laboratory approved by the Engineer.

iii) Re-test

Should any of the test specimens provided in accordance with the requirements listed in paragraph (1) above fail to meet the test requirements, the Contractor will be allowed a re-test on two additional specimens for each specimen that failed, and the pipe will be acceptable only when all the these retested specimens meet the strength requirements.

501.3.9 **Rejection**

Pipes shall be subject to rejection on account of failure to conform to any of the above specification requirements or on account of any of the following:-

1) Fractures or cracks passing through the shell, except that a single end crack that does not exceed the depth of the joint shall not be cause for rejection. If a single end crack that does not exceed the depth of the joints exist in more than ten (10) per cent of the pipes inspected, however, the defective pipes shall be
rejected.

ii) Defects that indicate imperfect mixing and moulding.

iii) Surface defects indicating honeycombing or open texture and exposure of reinforcement including rust marks caused by inadequate concrete cover.

iv) Spalls deeper than one half the depth of the joint or extending more than ten (10) cm around the circumference. If spalls not deeper than one half of the joint or extending not more than ten (10) cm around the circumference exist in more than ten (10) per cent of the pipes, however, the defective pipes shall be rejected.

v) Misplaced reinforcement already exposed or verified by checking
with an approved concrete reinforcement cover meter.

501.4 CONSTRUCTIONREQUIREMENTS

501.4.1 Excavation

A trench shall be excavated to the depth and grade established by the Drawings. The bottom of the trench shall be shaped to conform to the shape of the pipe for at least twenty(20) percent of its outside diameter. The width of the trench shall not be greater than two(2) times the pipe diameter, to permit satisfactory jointing and thorough tamping of the bedding material specified in item 502 under and around the pipe. Recesses shall be excavated for any bells involved. Where rock or hardpan is encountered, the trench shall be excavated to a depth at least (30) centimeters below the grade established for the bottom of the pipe. This excess depth shall be refilled with approved material and thoroughly compacted.

Where in the opinion of the Engineer, the natural foundation soil is such as to require stabilization, such material shall be replaced by a layer of suitable material. Where an unsuitable material (peat, mulch, etc.) is encountered at or below invert elevation during excavation, the necessary subsurface exploration and analysis shall be made and corrective treatment shall be as directed by the Engineer.

501.4.2 Placing Pipe

The pipe shall be laid carefully, bell up-grade, ends fully and closely jointed, and true to the elevations and grades given. Proper facilities shall be provided for lowering the sections when they are to be placed in a trench. Each section shall be securely attached to the adjoining sections by the method specified for the type of joint used. All joints, unless otherwise specified, shall be filled with stiff mortar composed of one part Portland cement and two parts sand. The mortar shall be placed so as to form a durable, watertight joint around the whole circumference of the pipe. After each section of pipe is laid and before the succeeding section is laid the lower portion of the bell shall be plastered thoroughly on the inside with mortar to such depth as to

bring the inner surface of the abutting pipe flush and even. After the section is laid, the remainder of the joint shall be filled with mortar and sufficient additional mortar shall be used to form a bead around the outside of the joint. The inside of the joint shall then be wiped and finished smooth. After the initial set, the mortar on the outside shall be protected from the air and sun with a cover of thoroughly wetted earth or burlap. Any pipe, which is not true in alignment or which shows any undue settlement after being laid, or is damaged, shall be taken up and relaid or replaced without extra payment. All joints, including any connections, shall be capable of transferring the required shear across the point.

501.4.3 **Backfilling**

After the pipe has been installed and the mortar joints sufficiently set, granular material (sand) and / or selected material from roadway excavation or borrow shall be placed alongside the pipes in layers not exceeding twenty (20) cms in depth and compacted to minimum ninety (90) percent of the maximum dry density determined as per AASHTO TA 91 Method, so that on each side of the pipe there shall be thoroughly compacted material at least as wide as the external diameter of the pipe except insofar as undisturbed material obtrudes upon this width. Each layer shall be moistened, if dry, and then compacted by tamping with mechanical hammers or by hand tamping with heavy iron tampers to the densities as specified under item 108.3.1 -Formation of Embankment with Common Material. This method of filling and compacting shall be continued until the embankment has reached an elevation of twenty (20) cms above the top of the pipe. When construction calls for placing a high embankment over the pipes, special instructions regarding the method of back filling shall be given by the Engineer.

501.4.4 **Construction Plant**

Movement of Construction equipment, over a culvert shall be at the contractor's risk. Any pipe injured thereby shall be repaired or placed at the contractor's cost.

501.5 **Headwalls**

Where indicated on the Drawings, the ends of the pipe culverts shall be protected by concrete or masonry headwalls constructed as shown on the Drawings. When headwalls are constructed, the ends of the pipe shall be neatly cutoff flush with the outside face of the headwalls,

501.6 MEASUREMENT AND PAYMENT

501.6.1 Measurement

The quantities to be paid for. shall be the number of linear meters of pipe placed, completed and accepted.

Payment shall be made separately under Item 502 for furnishing and installing granular material or concrete in the bed of the culvert as shown on the Drawings.

501.6.2 Payment

The quantities, as measured above, shall be paid for at the' contract unit price respectively, for each of the particular pay items listed below in the BOO. Payment shall. be full compensation for furnishing and placing all materials including mortar for joints, for excavating trenches and backfilling, and for all other costs necessary or usual to the proper completion of the work prescribed in this item. Headwalls, wing-walls and aprons together with the bedding for the concrete pipe culvert, will be measured and paid for separately.

Pay Item No.	Description	Unit of Measurement
	AASHTO M 170, Class II Reinforced Concrete Pipe	
501a	Diameter 310 mm	M
501b	Diameter 380 mm	M
501c	Diameter 460 mm	M
501d	Diameter 610 mm	M
501e	Diameter 760 mm	M
501f	Diameter 910 mm	M
501g	Diameter 1070 mm	M
501h	Diameter 1220 mm	M
501i	Diameter 1520 mm	M
	AASHTO M 170, Class IV Reinforced Concrete Pipe	
501j	Diameter 310 mm	M
501k	Diameter 380 mm	M
501l	Diameter 460 mm	M
501m	Diameter 610 mm	M
501n	Diameter 760 mm	M
501o	Diameter 910 mm	M
501p	Diameter 1070 mm	M
501q	Diameter 1220 mm	M
501r	Diameter 1520 mm	M

ITEM 601 CONCRETE KERBS, GUTTERS AND CHANNELS

601.1 DESCRIPTION

This work shall consist of 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. The kerb, gutter, channel or in combination may be constructed by one of the following methods.

i) Cast in place concrete kerbing.
ii) Precast concrete kerbing.
iii) Extruded concrete kerbing.

601.2 MATERIAL REQUIREMENTS

The concrete for cast in place concrete kerbs, gutters and channels shall be either Class W or class 'C' or as indicated on the Drawings and shall conform to the requirements of that particular class prescribed under item 401.1.1. "Classes of concrete". 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 consist of class 'C' concrete conforming to the requirement of item 401 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 meter 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 under item 403-Formwork.

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. Steel Reinforcement if required shall conform to item 404 "Steel Reinforcement".

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

601.3 CONSTRUCTION REQUIREMENTS

601.3.1 **Cast-in-Place**

a) Excavation and Bedding

Excavation shall be made to the required depth and the base upon which the kerb or combination of kerb and gutter is to be set shall be compacted to a minimum density of ninety (90) percent of the maximum dry density as determined by AASHTO T-191 Method. All soft and unsuitable material shall be removed and replaced with suitable material acceptable to the Engineer.

Where directed by the Engineer, a layer of cinders or clean sand and gravel, or other approved porous material having a minimum compacted thickness, of fifteen (15) cm shall be placed to form a bed for the kerb or combination of kerb and gutter.

b) Placing Concrete

Concrete may be placed in the gutter to the full depth required. The top of the kerb or combination of kerb and gutter shall be floated smooth and the edges rounded to the radii shown on the Drawings. Before finishing, the surface of the gutter shall be tested with a three (3) meter straight-edge and any irregularities of more than five (5) mm in three (3) meters shall be eliminated. In finishing concrete only mortar normally present in the concrete shall be permitted for finishing. The use of a separate mortar finishing coat or the practice of working dry cement into the surface of the concrete will not be permitted.

c) Joints

The kerb and gutter shall be constructed in uniform sections of not more than twenty five (25) meters in length except where shorter sections are required to coincide with the location of weakened planes or contraction joints Of the concrete pavement or for closures but no section shall be less than two (2) meters long. The sections shall be separated by sheet templates set perpendicular to the face and top of the kerb and gutter. The templates shall be approximately five (5) mm in thickness, of the same width as that of the kerb or kerb and gutter and not less than five (5) cm greater than the depth of the kerb or kerb and gutter. Templates shall be set carefully and held firmly during the placing of the concrete and shall be allowed to remain in place until the concrete has set sufficiently to hold its shape, but shall be removed while the forms are still in place. When pre-cut fiber-board packing is used in the expansion joints it may be used in place of the sheet template referred to above, on the approval of the Engineer. In this event the fiber board

shall be pre-cut to the shape of the kerb so that its outer edge will be flush with the abutting kerb.

Expansion joints shall be formed in the kerb and gutter at intervals of six (6) to ten (10) meters in order to coincide with the expansion joints of cement concrete pavement or as shown on the Drawing.

d) Dowels at Expansion Joints in Channels

At expansion joints in channels and in the channel portion of kerbs and channel built monolithically, painted dowel bars with slip sleeve shall be provided as a load transfer medium at locations shown on the Drawings.

The size and spacing of the dowel bars shall be as indicated on the Drawings. Each dowel shall be set accurately parallel to the top surface of the gutter and accurately at right angles to the expansion joint.

e) Contraction Joints

Transverse contraction joints shall be provided opposite to all contraction joints in abutting concrete pavement and other locations shown on the Drawing spaced to a maximum of four (4) meters.

The contraction joints shall be provided by forming grooves in the face and surface of structure at right angle to the kerb alignment and kerb surface. The grooves shall be rectangular in cross-section, five (5) cm deep by five (5) cm wide. The grooves shall be formed in the top of all kerbs and in the exposed roadway face of kerb and in the channel surface of monolithic type kerb and channels and in the surface of channels. The edges of the joints shall be tooled and the joints shall be left clean, neat and of specified width and depth.

f) Removal of Forms and Finishing

The forms shall be removed within twenty four (24) hours after concrete has placed except that the, form used against the face of the kerb in a combination of kerb and gutter shall be removed as soon as the concrete has set sufficiently to hold its shape. Minor defects shall be repaired with mortar containing one part of portland cement and two parts of the fine aggregate. Plastering shall not be permitted on the face of a kerb or kerb and gutter and all rejected kerb or gutter shall be removed and replaced without additional compensation. Ail surfaces which will be exposed in the finished construction of the kerb and gutter shall be finished, while the concrete is still "green" by wetting a wood block of float and rubbing the surface until they are smooth.

g) Curing

During seventy two (72) hours following placing of concrete, the kerbs, channels and gutters shall be protected against premature drying by covering with suitable cotton or Hessian mats and by frequent sprinkling with water, with liquid forming compounds or with waterproof paper or by any other method as mentioned in section 401.3.8-Curing, Concrete and approved by the Engineer.

h) 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) cms each until firm and solid.

601.3.2 **Pre-Cast**

a) 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 he Engineer.

Bedding shall consist of Class B Concrete conforming to the requirements of Item 401 and shall be to the section and dimension shown on the Drawings.

b) 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.

c) 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.

d) Backfilling

Backfilling shall meet the requirements of Item 601.3.1 (h).

601.3.3 **Extruded Concrete Kerbing and Channels**

a) Excavation and Bedding

Excavation and bedding shall conform to the requirements as described under item 601.3.1 (a).

b) Placing

Concrete shall be fed to the machine at a uniform rate. The concrete shall be of such consistency that after extrusion it will maintain the shape of the kerb section without support and shall contain the maximum amount of water that will permit this result. The machine shall be operated under sufficient uniform restraint to forward motion to produce a we!] compacted mass of concrete which requires no further finishing other than light brushing with a brush filled with water only. The forming tube portion of the extrusion machine shall be readily adjustable vertically during the forward motion of the machine. A grade line gauge or pointer shall be attached to the machine so that a continual comparison can be made between the kerb being placed and the established kerb grade as indicated by an offset guideline.

The top end face of the finished kerb shall be true and straight and the top surface of the kerb shall be of uniform width, free from bumps or surface pits larger than fifteen (15) mm in diameter. When a straight-edge three (3) meters long is laid on the top or face of the kerb. or surface of the gutter, the surface shall not be more than five (5) mm from the edge of the straightedge except at grade changes or curves.

Where adhesive is used to bond the kerb to an ~existing pavement, the surface shall be first thoroughly cleaned of all dust, loose material and oil, the cost of which shall be included in other items of work.

c) Joints

Expansion joints shall be constructed by sawing through the kerb section to its full depth. The width of the cut shall be such as to admit the joint filter with a tight fit. Preformed joint filler shall conform to the provisions of Item 601.2 and shall be inserted and mortared in place.

If sawing is performed before the concrete has hardened, the adjacent portion of the kerb shall be supported firmly with close fitting shields and the operations of sawing and inserting the joint filler shall be completed before curing the concrete.

Alternatively pre-cut joint fillers shall be permitted to be placed at the location of the expansion joints prior to the placing of the extruded kerb with the approval of the Engineer. The joint fillers shall be set firmly in place in a vertical position to the line and grade of the kerb profile.

d) Curing and Backfilling

Curing and backfilling shall be as described in item 601.3.1(g) and Item 601.3.1 (h).

601.4 MEASUREMENT AND PAYMENT

601.4.1 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 meter 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.

601.4.2 **Payment**

Measured and accepted quantities shall be paid for at the contract unit price per linear meter for each of the particular pay item listed below and 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 price tendered per linear meter for the kerbs and channels and shall not be paid for separately.

Concrete and mortar required for bedding of precast concrete kerbs as shown on the Drawings shall not be paid for as separated item, but the cost shall be included in the contract unit price for precast concrete kerb.

Pay Item No.	Description	Unit of Measurement
601a	Concrete Kerb, in place, Type ____	M
601b	Combination of Kerb and Gutter in Place, Type ____	M
601c	Combination of Kerb and Channel in Place, Type ____	M
601d	Pre-Cast Kerb in Place, Type_____	M
601e	Concrete Channel, Type_____	M
601f	Extuded Kerb and Channel, Type	M

ITEM 613 SPRIGGING AND SODDING

613.1 DESCRIPTION

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.

613.2 MATERIAL REQUIREMENTS

613.2.1 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 woods, 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.

613.2.2 Springs

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.

613.2.3 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).

613.3 CONSTRUCTION REQUIREMENTS

613.3.1 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.

613.3.2 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:

i) 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.

ii) 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.

c) 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.

613.3.3 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.

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 steeper than one meter 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) Ton 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.

613.4 MEASUREMENT AND PAYMENT

613.4.1 Measurement

The work of sprigging, sodding and top soiling shall each be measured by the square meter, 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 Item 103 for "Stripping".

613.4.2 Payment

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

Pay Item No.	Description	Unit of Measurement
613a	Sprigging	Sq.m.
613b	Sodding	Sq.m.
613c	Top Soil	Sq.m.

SCHEDULE FOR SAMPLING AND TESTING OF EMBANKMENT AND SUBGRADE (ITEM NO. 108 AND 113)

Material	Test	Designation	Sampling and Testing Frequency	Reference
Soil	Classification	AASHTO M-145	1/2,000 CM	As per item 108.2 109.2.5 110.2 etc.
	CBR	AASHTO T-193	1/2,000 CM	As per item 108.2 and 110.2 etc.
	Swelling	AASHTO T-193	1/2,000 CM	As per item 108.2 ©
	Moisture Density (Lab) or	AASHTO T-180	1/2,000 CM	As per item 108.3
	Relative Density	ADTM D-4254-83	1/1,000 CM	109.2.2 etc. ref. Density
	Field Density	AASHTO T-191	1/200 CM	As per item 108.3 109.2.2 etc.

SCHEDULE FOR SAMPLING AND TESTING OF GRANULAR SUBBASE (ITEM NO. 201)

Material	Test	Designation	Sampling and Testing Frequency	Reference
Aggregate	Gradation	AASHTO T-27	3/Source plus 1/1000 M	As per item 201.2
	Plasticity Index	AASHTO T-89 and T-90	3/Source plus as required based on visual observation	- do -
	CBR	AASHTO T-193	3/Source plus as required based on variation in gradation or 1/1000 CM	- do -
	Abrasion	AASHTO T-96	3/Source plus 1/500 CM	- do -
	Moisture Density	AASHTO T-180	1/1000 CM	- do -
	Field Density	AASHTO T-191	4/layer/400 M laid, 3 minimum / layer if less than 400 m laid	As per item No. 201.32.4
	Sand Equipment	AASHTO T-176	3/Source plus as required based on visual observation	As per item No. 201.2

SCHEDULE FOR SAMPLING AND TESTING OF AGGREGATE BASE COURSE (ITEM NO. 202)

Material	Test	Designation	Sampling and Testing Frequency	Reference
Aggregate	Gradation	AASHTO T-27	3/Source plus 1/1000 M	As per item 202.2.(a)
	Plasticity Index	AASHTO T-89 and T-90	3/Source plus as required based on visual observation	As per item 202.2(a)
	CBR	AASHTO T-193	3/Source / stock pile plus as required base on variation in gradation	As per item 202.2(f)
	Abrasion	AASHTO T-96	3/Source plus 1/5,000 CM	As per item 202.2 ©
	Sodium Sulphate Soundness	AASHTO T-104	3/Source plus 1/5,000 CM	As per item 202.2 (d)
	Fractured faces	Visual	3/Source plus as required based on visual observation	As per item 202.2(b)
	Moisture Density	AASHTO T-180	1/1000 CM	As per item 203.3.3
	Field Density	AASHTO T-191 or T-238 and T-239	3/Layer/400 M laid 3 minimum /layer if less than 400 M Laid	As per item 202.3.3
	Sand Equipment	AASHTO T-176	3/Source plus as required based on visual observation	As per item 202.2(e)

SCHEDULE FOR SAMPLING AND TESTING OF ASPHALTIC BASE COURSE PLANT MIX (ITEM NO. 203)

Material	Test	Designation	Sampling and Testing Frequency	Reference
Mixture Compacted]in place	Thickness	AASHTO T-230	1/layer @ 100M interval per lane	As per item 203.3.11
Mixture	Compaction	AASHTO T-230 ASTM D2950	1/layer @ 100M interval per lane	As per item 203.3.9

Note:

a) Test locations will be selected a random.

SCHEDULE FOR SAMPLING AND TESTING OF ASPHALTIC BASE COURSE PLANT MIX (ITEM NO. 203)

Material	Test	Designation	Sampling and Testing Frequency	Reference
Coarse Aggregate	Gradation	AASHTO T-27	1/1000 CM	
	Abrasion	AASHTO T-96	3/Source/Stock pile plus 1/5000 CM	As per Item 203.2.1 (a)
	Sodium Sulphate Soundness	AASHTO T-104	3/Source/Stock pile plus	As per Item 203.2.1 (b)
	Stripping	AASHTO T-182	3/Source plus 2/5000 CM	---
	Fractured faces	Visual	3/Source plus as required based on visual observation	As per Item 203.2.1
	Flat and Elongated Particle	Visual	3/Source plus as required based on visual observation	As per Item 203.2.1 (e)
	Specific Gravity and Absorption	AASHTO T-85	4/Source for each size in Hot bins of Asphalt Plant	For use in preparation of JMF
Fine Aggregate	Sand Equivalent or Plasticity Index	AASHTO T-176 AASHTO T-89 and T-90	3/Source plus as required based on visual observation 2/1000 CM	As per Item 203.2.1 © As per Item 203.2.1 (d)
	Specific Gravity	AASHTO T-84	4/Source	For use in preparation of JMF
	Friable Particles	AASHTO T-112	2/5000 CM	--
Asphalt Cement	Specific Gravity	AASHTO T-228	2/Shipment	For use in preparation of JMF
	Penetration	AASHTO T-49	2/Week of plant operation Samples taken from heating tank at staggered intervals.	As per item 203.2.2
Mixture	Extraction Gradation Bulk Sp. Gr.	AASHTO T-164 T-30 AASHTO T-166 Method-B		
	Maximum Sp. Gr.	AASHTO T-209	2/day's production	As per item 203.2.3
	Air Voids	AASHTO T-269		

TABLE FOR ALLOWABLE TOLERANCES
(EARTHWORKS, PAVEMENT COURSES AND CONCRETE)

Material	Test	Designation	Sampling and Testing Frequency	Acceptance Limit
Cement	Yield Test for Cement Content	AASHTO T-121	1/Lot or 1000 Bags	As per Item 310.3.3
	Setting Time	AASHTO T-131	1/Lot or 1000 Bags	As per Item 401.2.1
	Mortar Strength	AASHTO T-132	1/Lot or 1000 Bags	As per Item 401.2.1
Water	Chemical Tests	AASHTO T-26	1/Source	As per Item 401.2.7
Concrete Mix	Compression (Cube or Cylinder)	AASHTO T-22	6/Shift or 50 CM (2 sets of 3 each)	As per Item 401.1.1. Table 401.10
	Slump	AASHTO T-119	2/Shift or 50 CM	As per Item 401.1.1. Table 401.10

SCHEDULE FOR SAMPLING AND TESTING OF CONCRETE
(ITEM NO. 401)

Material	Test	Designation	Sampling and Testing Frequency	Acceptance Limit
Course Aggregate	Gradation	AASHTO T-27	2/Stockpile Plus 1/1000 CM	As per Item 401.2.3
	Unit Wt.	AASHTO T-19	1/Source Plus 1/1000 CM	For use in preparation of mix design
	Sp. Gravity	AASHTO T-85	2/Source Plus 1/1000 CM	- do -
	Absorption	AASHTO T-85	1/Source Plus 1/500 CM	- do -
	Abrasion	AASHTO T-96	1/Source Plus 1/5000 CM	As per item 401.2.3
	Soundness	AASHTO T-104	1/Source Plus 1/5000 CM	As per item 401.2.3
	Deleterious Substance	AASHTO T-80	1/Source Plus 1/5000 CM	As per item 401.2.3
Fine Aggregate	Gradation	AASHTO M-6	2/Source Plus 1/1000 CM	As per item 401.2.2
	Unit Wt.	AASHTO T-19	4/Source Plus 1/800 CM	For use in Preparation of mix design
	Specific Gravity	AASHTO T-84	4/Source Plus 1/1000 CM	- do -
	Absorption	AASHTO T-84	1/Source Plus 1/1000 CM	- do -
	Organic Impurities	AASHTO T-21	1/Source Plus 1/1000 CM	As per item 401.3.9 and 401.2.2
	Soundness	AASHTO T-104	1/Source Plus 1/5000 CM	-
	Fitness	AASHTO M-6	1/Source Plus 1/1000 CM	As per item 401.2.2
	Deleterious Substance	AASHTO M-8	1/Source Plus 1/5000 CM	As per item 401.2.2
	Petrographic	-	1/Source Plus 1/5000 CM	-

TABLE FOR ALLOWABLE TOLERANCES
(EARTHWORKS, PAVEMENT COURSES AND CONCRETE)

Description	Thickness (mm)	Level (mm)	5M Straight-edge (mm)	Cross-fall (%)	Longitudinal Grade in 30M (%)
Sub-grade	± 20	± 0 -40	30	± 0.5	± 0.1
Subbase (Granular or Stabilized)	± 10 -20	± 0 -25	20	± 0.3	± 0.1
Base Course (Granular of Stabilized)	± 5 -10	± 5 -10	6	± 0.2	± 0.1
Asphaltic Base Course	± 3 -10	± 3 -10	6	± 0.2	± 0.1
Asphaltic Wearing Course	± 3	± 3	5	± 0.2	± 0.1
Concrete for Pavement	± 10 -5	± 10 -5	5	± 0.2	± 0.1
Concrete for Structures	± 5	± 10	5	___	___

Note: 1. Material for stabilization of soil may be cement, lime or bitumen

2. Accumulative tolerance shall not be more than as specified against the final layer.

SCHEDULE FOR SAMPLING AND TESTING OF EMBANKMENT AND SUBGRADE (ITEM NO. 108 AND 113)

Material	Test	Designation	Sampling and Testing Frequency	Reference
Soil	Classification	AASHTO M-145	1/2,000 CM	As per item 108.2 109.2.5 110.2 etc.
	CBR	AASHTO T-193	1/2,000 CM	As per item 108.2 and 110.2 etc.
	Swelling	AASHTO T-193	1/2,000 CM	As per item 108.2 ©
	Moisture Density (Lab) or	AASHTO T-180	1/2,000 CM	As per item 108.3
	Relative Density	ADTM D-4254-83	1/1,000 CM	109.2.2 etc. ref. Density
	Field Density	AASHTO T-191	1/200 CM	As per item 108.3 109.2.2 etc.

SCHEDULE FOR SAMPLING AND TESTING OF GRANULAR SUBBASE (ITEM NO. 201)

Material	Test	Designation	Sampling and Testing Frequency	Reference
Aggregate	Gradation	AASHTO T-27	3/Source plus 1/1000 M	As per item 201.2
	Plasticity Index	AASHTO T-89 and T-90	3/Source plus as required based on visual observation	- do -
	CBR	AASHTO T-193	3/Source plus as required based on variation in gradation or 1/1000 CM	- do -
	Abrasion	AASHTO T-96	3/Source plus 1/500 CM	- do -
	Moisture Density	AASHTO T-180	1/1000 CM	- do -
	Field Density	AASHTO T-191	4/layer/400 M laid, 3 minimum / layer if less than 400 m laid	As per item No. 201.32.4
	Sand Equipment	AASHTO T-176	3/Source plus as required based on visual observation	As per item No. 201.2

SCHEDULE FOR SAMPLING AND TESTING OF AGGREGATE BASE COURSE (ITEM NO. 202)

Material	Test	Designation	Sampling and Testing Frequency	Reference
Aggregate	Gradation	AASHTO T-27	3/Source plus 1/1000 M	As per item 202.2.(a)
	Plasticity Index	AASHTO T-89 and T-90	3/Source plus as required based on visual observation	As per item 202.2(a)
	CBR	AASHTO T-193	3/Source / stock pile plus as required base on variation in gradation	As per item 202.2(f)
	Abrasion	AASHTO T-96	3/Source plus 1/5,000 CM	As per item 202.2 ©
	Sodium Sulphate Soundness	AASHTO T-104	3/Source plus 1/5,000 CM	As per item 202.2 (d)
	Fractured faces	Visual	3/Source plus as required based on visual observation	As per item 202.2(b)
	Moisture Density	AASHTO T-180	1/1000 CM	As per item 203.3.3
	Field Density	AASHTO T-191 or T-238 and T-239	3/Layer/400 M laid 3 minimum /layer if less than 400 M Laid	As per item 202.3.3
	Sand Equipment	AASHTO T-176	3/Source plus as required based on visual observation	As per item 202.2(e)

SCHEDULE FOR SAMPLING AND TESTING OF ASPHALTIC BASE COURSE PLANT MIX (ITEM NO. 203)

Material	Test	Designation	Sampling and Testing Frequency	Reference
Mixture Compacted]in place	Thickness	AASHTO T-230	1/layer @ 100M interval per lane	As per item 203.3.11
Mixture	Compaction	AASHTO T-230 ASTM D2950	1/layer @ 100M interval per lane	As per item 203.3.9

Note:

a) Test locations will be selected a random.

SCHEDULE FOR SAMPLING AND TESTING OF ASPHALTIC BASE COURSE PLANT MIX (ITEM NO. 203)

Material	Test	Designation	Sampling and Testing Frequency	Reference
Coarse Aggregate	Gradation	AASHTO T-27	1/1000 CM	
	Abrasion	AASHTO T-96	3/Source/Stock pile plus 1/5000 CM	As per Item 203.2.1 (a)
	Sodium Sulphate Soundness	AASHTO T-104	3/Source/Stock pile plus	As per Item 203.2.1 (b)
	Stripping	AASHTO T-182	3/Source plus 2/5000 CM	---
	Fractured faces	Visual	3/Source plus as required based on visual observation	As per Item 203.2.1
	Flat and Elongated Particle	Visual	3/Source plus as required based on visual observation	As per Item 203.2.1 (e)
	Specific Gravity and Absorption	AASHTO T-85	4/Source for each size in Hot bins of Asphalt Plant	For use in preparation of JMF
Fine Aggregate	Sand Equivalent or Plasticity Index	AASHTO T-176 AASHTO T-89 and T-90	3/Source plus as required based on visual observation 2/1000 CM	As per Item 203.2.1 © As per Item 203.2.1 (d)
	Specific Gravity	AASHTO T-84	4/Source	For use in preparation of JMF
	Friable Particles	AASHTO T-112	2/5000 CM	--
Asphalt Cement	Specific Gravity	AASHTO T-228	2/Shipment	For use in preparation of JMF
	Penetration	AASHTO T-49	2/Week of plant operation Samples taken from heating tank at staggered intervals.	As per item 203.2.2
Mixture	Extraction Gradation Bulk Sp. Gr.	AASHTO T-164 T-30 AASHTO T-166 Method-B		
	Maximum Sp. Gr.	AASHTO T-209	2/day's production	As per item 203.2.3
	Air Voids	AASHTO T-269		

TABLE FOR ALLOWABLE TOLERANCES
(EARTHWORKS, PAVEMENT COURSES AND CONCRETE)

Material	Test	Designation	Sampling and Testing Frequency	Acceptance Limit
Cement	Yield Test for Cement Content	AASHTO T-121	1/Lot or 1000 Bags	As per Item 310.3.3
	Setting Time	AASHTO T-131	1/Lot or 1000 Bags	As per Item 401.2.1
	Mortar Strength	AASHTO T-132	1/Lot or 1000 Bags	As per Item 401.2.1
Water	Chemical Tests	AASHTO T-26	1/Source	As per Item 401.2.7
Concrete Mix	Compression (Cube or Cylinder)	AASHTO T-22	6/Shift or 50 CM (2 sets of 3 each)	As per Item 401.1.1. Table 401.10
	Slump	AASHTO T-119	2/Shift or 50 CM	As per Item 401.1.1. Table 401.10

SCHEDULE FOR SAMPLING AND TESTING OF CONCRETE
(ITEM NO. 401)

Material	Test	Designation	Sampling and Testing Frequency	Acceptance Limit
Course Aggregate	Gradation	AASHTO T-27	2/Stockpile Plus 1/1000 CM	As per Item 401.2.3
	Unit Wt.	AASHTO T-19	1/Source Plus 1/1000 CM	For use in preparation of mix design
	Sp. Gravity	AASHTO T-85	2/Source Plus 1/1000 CM	- do -
	Absorption	AASHTO T-85	1/Source Plus 1/500 CM	- do -
	Abrasion	AASHTO T-96	1/Source Plus 1/5000 CM	As per item 401.2.3
	Soundness	AASHTO T-104	1/Source Plus 1/5000 CM	As per item 401.2.3
	Deleterious Substance	AASHTO T-80	1/Source Plus 1/5000 CM	As per item 401.2.3
Fine Aggregate	Gradation	AASHTO M-6	2/Source Plus 1/1000 CM	As per item 401.2.2
	Unit Wt.	AASHTO T-19	4/Source Plus 1/800 CM	For use in Preparation of mix design
	Specific Gravity	AASHTO T-84	4/Source Plus 1/1000 CM	- do -
	Absorption	AASHTO T-84	1/Source Plus 1/1000 CM	- do -
	Organic Impurities	AASHTO T-21	1/Source Plus 1/1000 CM	As per item 401.3.9 and 401.2.2
	Soundness	AASHTO T-104	1/Source Plus 1/5000 CM	-
	Fitness	AASHTO M-6	1/Source Plus 1/1000 CM	As per item 401.2.2
	Deleterious Substance	AASHTO M-8	1/Source Plus 1/5000 CM	As per item 401.2.2
	Petrographic	-	1/Source Plus 1/5000 CM	-

TABLE FOR ALLOWABLE TOLERANCES
(EARTHWORKS, PAVEMENT COURSES AND CONCRETE)

Description	Thickness (mm)	Level (mm)	5M Straight-edge (mm)	Cross-fall (%)	Longitudinal Grade in 30M (%)
Sub-grade	± 20	± 0 -40	30	± 0.5	± 0.1
Subbase (Granular or Stabilized)	± 10 -20	± 0 -25	20	± 0.3	± 0.1
Base Course (Granular of Stabilized)	± 5 -10	± 5 -10	6	± 0.2	± 0.1
Asphaltic Base Course	± 3 -10	± 3 -10	6	± 0.2	± 0.1
Asphaltic Wearing Course	± 3	± 3	5	± 0.2	± 0.1
Concrete for Pavement	± 10 -5	± 10 -5	5	± 0.2	± 0.1
Concrete for Structures	± 5	± 10	5	___	___

Note: 1. Material for stabilization of soil may be cement, lime or bitumen

2. Accumulative tolerance shall not be more than as specified against the final layer.