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21 ROAD AND ROAD STRUCTURES

21.1 CONSTRUCTION OF ROADS

21.1.1 EARTHWORK

21.1.1.1 General

The earthworks for Construction of Roads shall generally conform to the provisions of Section 3, Earthwork subject to the further provisions stated hereunder. AASHTO (American Associations State Highways) Specifications shall apply for construction of roads unless otherwise specified.

21.1.2 CLEARING & GRUBBING

The clearing & grubbing required for construction of roads shall be carried out in accordance with applicable provisions of Clause 3.10 under Section 3 – Earthwork.

21.1.3 STRIPPING

21.1.3.1 General

This work shall consist of removing, transporting and depositing top soil in stock piles or spreading where indicated on the drawings or as directed by the Engineer-in-Charge.

21.1.3.2 Construction Requirement

The areas from which stripping of top soil is required shall be as indicated on the drawings or as directed by the Engineer-in-Charge. The Contractor shall remove top soil from these areas to depth as directed by the Engineer-in-Charge. Stripping of top soil in any case shall be not less than 4 inches (10 cm) in depth. The removed top soil shall be transported, deposited in stock piles at locations designated by the Engineer-in-Charge and/or spread where indicated on the drawings or as directed by the Engineer-in-Charge. Stripped material at stock pile shall not be used by the Contractor.

The top soil shall be placed separately from other excavated materials and be completely removed to the required depth from the area prior to the beginning of regular excavation or embankment work in that area. No payment will be made for top soil removed from places other than that directed by the Engineer-in-Charge.

21.1.4 COMPACTION OF NATURAL GROUND

21.1.4.1 General

The surface ready for construction purposes after cleaning 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-in-Charge.

21.1.4.2 Construction Requirements

Up to a depth of 12 inches (30 cm) below the natural ground, all sods and vegetable materials shall be removed and cleared surface shall be broken up by ploughing and scarifying to compact to 95 percent of maximum Dry density as determined by AASHTO T-180.

21.1.5 ROADWAY & BORROW EXCAVATION FOR EMBANKMENT

21.1.5.1 Roadway Excavation

Roadway excavation shall comprise all excavation that is not classified as structural excavation carried out within the limits of roadway including permanent drainage ditches and side slope cuts. The classification of the excavation shall conform to the provisions of Clause 3.1 under Section 3 of Earthwork.

21.1.6 BORROW EXCAVATION

21.1.6.1 General

Borrow excavation shall be taken for construction of embankments and backfills where necessary and shall comply with the provisions of Clause 3.8.3, Section 3 – Earthwork.

21.1.7 CONSTRUCTION REQUIREMENT

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

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

During construction of the roadway, the road shall be maintained in such a condition that it will be well drained at all times. All slopes, except in solid rock or other material shall be trimmed precisely as per cross-sections and care must be exercised that no material shall be loosened beyond the required slopes. In blasting rock slopes a reasonably uniform face shall be left, regardless of whether or not the excavation is carried beyond the specified side slope. All breakage and sides shall be removed by the Contractor and disposed of as directed by the Engineer-in-Charge.

Rock, shale and other unsuitable road bed material encountered in cuts shall be excavated to require width and depth indicated on the plans or as otherwise directed. Any over- breakage below the depth shown on the plans will not be paid for. Backfill of the over-cut shall be of approved earth material and shall have the same density requirements as specified on the plans and shall be at the expense of Contractor.

Borrow-pits shall be located so that the nearest edge of the pit is at, least thirty (30) meters from the roadway toe of slope unless otherwise directed by the Engineer-in-Charge. Permission to use any borrow material including its suitability, shall be obtained in writing from the Engineer-in-Charge at-least fifteen days in advance of the proposed date of taking borrow materials.

In no case shall borrow material be obtained from downstream of any hydraulic structure. However the borrow-pit may be established at five hundred (500) meters upstream of the hydraulic structure. The side slopes of the pits or channels shall be constructed as shown on the plans or directed by the Engineer-in-Charge. In no case the side slopes of borrow pit be steeper than a slope; 1:5 (V:H).

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

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

Rock material above ground level such as stones, boulders, piles of stone, and dry stones walling whose individual sizes are greater than one quarter of a cubic meter shall be removed and disposed of if directed in. writing by the Engineer-in-Charge. When the Contractor is directed to excavate unsuitable material below the surface of original ground in fill areas other than required for cleaning and grubbing, the depth to which these unsuitable materials are to be removed will be determined by the Engineer-in-Charge. The Contractor shall schedule his work in such a way that authorized cross-sections can be taken before and after the material has been removed.

The excavation in rock shall be carried out strictly in conformity with provisions of Sub-Section 3.6 of Section 3 – Earthwork.

21.1.8 EMBANKMENT CONSTRUCTION

21.1.8.1 General

The 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 road-way area in accordance with the specifications and in conformity with the lines, grades, thickness and typical cross-section shown on the plans or established by the Engineer-in-Charge.

21.1.8.2 Material Requirements

Material for embankment shall consist of suitable material excavated from road way excavation or structural excavation or borrow. Borrow material will be used only when material obtained from roadway or structural excavation is not suitable or is deficient for embankment formation.

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, A-5, soil as specified in AASHTO M-145 or other material approved by the Engineer-in-Charge.
- b) C.B.R. of the material shall not be less than five (5) percent, determined in accordance with AASHTO T-193. 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 0.3 percent. In case sandy material be used for embankment formation, it shall be properly confined with a material approved by the Engineer-in-Charge and 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 A-1 or A-2, soils. Other soils may be used only with the written consent of Engineer-in-Charge.
- e) For the purpose of embankment and sub-grade construction, the following shall be considered as unsuitable materials:
 - Material from soil AASHTO classification group A-6 and A-7.
 - Material from swamps, marshes and bogs.
 - Peat, logs, stumps and perishable materials.
 - Organic soils.
 - Material having a C.B.R value less than 7% determined according to AASHTO T-193, for the embankment depth of 30 cm below sub-grade.

21.1.8.3 Construction Requirements

a) Formation of Embankment with Common Material

Material for embankment, obtained and approved as provided above, shall be placed in horizontal layers of uniform thickness and in conformity with the lines, grades, sections and dimensions shown on the drawings or as required by the Engineer-in-Charge. The layers of loose material other than rock shall be not more than 20 cm thick unless otherwise allowed by the Engineer-in-Charge after a trial section is prepared and approved. The material placed in layers and scarified to the designated depth for formation of embankment shall be compacted to the density specified below:

Depth in centimetres below sub-grade level	Percent of Maximum Dry Density as Determined by AASHTO T-180
0 to 30	95
30 to 75	93
Over 75	90

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 19 mm($\frac{3}{4}$ inch) sieve, the in place density thus obtained shall be adjusted to account for such oversize particles as or directed by the Engineer-in-Charge. Subsequent layers shall not be placed and compacted unless the previous layer has been properly compacted and accepted by the Engineer-in-Charge.

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

The compaction of the embankment shall be carried out at the designated moisture content consistent with the available compacting equipment. Embankment material that does not contain sufficient moisture shall be given additional moisture by means of approved sprinklers and mixing to obtain the required compaction. Material containing more than the optimum moisture may not, without written approval of the Engineer-in-Charge, be incorporated in the embankment until it has sufficiently dried out. The drying of wet material may be expedited by the scarifier dishing 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-in-Charge. 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-in-Charge, and the finished work shall be left in a neat and acceptable conditions.

b) 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 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) cm. 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.

c) 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, rolling or scarifying by approved mechanical means to a level to be determined by the Engineer-in-Charge. 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 by the Engineer-in-Charge. The payment for incorporation of such item shall be decided by the Engineer-in-Charge.

d) 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 (75mm)	100

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

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

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-in-Charge, 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-in-Charge.

No density requirements are specified for the working platform, however, subsequent layers above it shall be compacted to the densities specified in 21.1.8.3.

e) Formation of Embankment with Rock Material

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

Mass per metre 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-in-Charge.

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

Embankments, which are formed of material that contain rock but also contain sufficient compactable material other than rock or other hard material to make rolling feasible, shall be placed and compacted in the manner prescribed above and to the point when settlement is within above mentioned requirement. Compaction test will be made whenever the Engineer-in-Charge 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.

f) General Requirements

To avoid interference with the construction of bridge abutments and wing walls, the Contractor shall at points determined by the Engineer-in-Charge, suspend work on embankment 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 bridges, culverts or pipe drainage, care shall be taken by the Contractor to have the embankments brought equally on both sides of any such structure. The contractor shall make special arrangements to ensure proper compaction in restricted spaces and around structures without any extra compensation for this work.

When as a result of settlement, an embankment requires the addition of material up to 30 cm in thickness to bring it up to the required grade level, the top of the embankment shall be thoroughly scarified before the additional material is placed, without extra payment to the 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-in-Charge have been damaged or displaced due to carelessness or neglect on the part of the Contractor. Embankment materials which may be lost or displaced as a result of natural causes such as storms, cloudburst or as 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 except that the quantity of material required will be paid for at the contract price for the type of material used.

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

The sub-grade preparation shall include that part of the work on which the sub-base is placed or, in the absence of sub-base, acts as the base of the pavement structure. It shall extend to the full

width of the road bed including the shoulders and lay-bys as indicated on the drawings or as specified herein.

21.1.9 SUB-GRADE PREPARATION

21.1.9.1 General

The sub-grade preparation shall include that part of the work on which the sub-base is placed or in the absence of sub-base acts as the base of the pavement structure. It shall extend to the full width of the road bed including the shoulders and lay-byes as indicated on the drawings or as specified herein.

21.1.9.2 Construction Requirements

a) Prior Works

Before commencing the work all structures such as culverts, drains, ditches (including fully compacted backfill over them) outlets for drainage, head walls/wing walls of culverts and any other minor structure which will be below thirty (30) centimetres of existing sub-grade level or all the structure which will be below (30cm) of newly placed sub-grade level, shall be in such operative conditions as to ensure prompt and effective drainage and to avoid damage to sub-grade by surface water.

No work of sub-grade preparation will be started before the prior work herein described has been approved by the Engineer-in-Charge.

b) Compaction Requirement

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

c) Sub-grade Preparation in Earth Cut

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

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

d) Sub-grade Preparation in Rock Cut.

Excavation in solid rock shall extend to at least fifteen (15) centimeters below the sub-grade level. Rock shall be undercut neatly to required elevation and sections shown on the plans or as directed by the Engineer-in-Charge. Transverse and longitudinal profile checked by template shall be accurate to the specification, Cuts below sub-grade level shall be backfilled with selected sub-base material and compacted to at minimum ninety eight (98) percent of the maximum dry density as determined by AASHTO T-189, method 'D' at Contractor's own cost.

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

e) Sub-grade in Embankment

When the sub-grade is formed in embankment, its width shall be the full width of top of embankment and material placed in the upper part of embankment down to a depth of thirty (30) centimetres below sub-grade level shall meet compaction requirement of Section (a). 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. The C.B.R less than 7% may be used in case, the design allows for it. Unsuitable material if encountered within the formation layer as per laboratory specified test, shall be removed, disposed of and replaced by suitable one as per direction of the Engineer-in-Charge for which no payment will be admissible to the Contractor. Rollers of approved size and type, accepted by the Engineer-in-Charge, shall be used for compaction. Water shall be added to obtain optimum moisture content, if necessary.

f) Sub-grade Level in Existing Roads

Where indicated on the drawings or directed by the Engineer-in-Charge that the existing road surface is to be used as the sub-grade, the correct elevation on which the base or sub-base is to be laid shall be obtained, where necessary, either by means of levelling course or by scarification. The levelling course shall be constructed to the requirements of the Engineer-in-Charge and paid for under the appropriate pay item involved. Scarification shall include disposal of any surplus material in the adjacent embankment or elsewhere as may be ordered by the Engineer-in-Charge. When the width of the new road is greater than that of the existing roads, surface shall be prepared as herein provided and the part that falls outside the existing road surface shall be prepared according to Sections (c), (d) and (e) above, or Section (g) below as the case may be.

g) Sub-grade Extension

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

The excavated material shall, if declared suitable for use elsewhere in the embankment by the Engineer-in-Charge be so used. If declared unsuitable it shall be disposed off.

h) Protection of Completed Sub-grade

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

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

(i) Templates and Straightedges, Tolerance Limits

The Contractor shall provide for the use of the Engineer-in-Charge, satisfactory templates and straight edges in sufficient numbers to check the accuracy of the work, as provided in these

specifications and no subsequent work shall be permitted until the sub-grade levels have been checked and approved by the Engineer-in-Charge. Tolerance limits shall be as follows:

Thickness + 20 mm, level + 0 & - 40 mm; 3 M straightedge 30 mm cross fall + 0.5 mm. Longitudinal grade in 30M + 0.1%.

21.1.9.3 Granular Sub-Base Course

21.1.9.4 General

The work under these specifications shall consist of furnishing, spreading in one or more layers and compacting granular sub-base according to the specifications and drawings and/or as directed by the Engineer-in-Charge.

21.1.9.5 Material Requirements

Granular sub-base 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 sub-base.

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

The sub-base material shall have a gradation curve within the limits for grading A, Band C given below. However grading A may be allowed by the Engineer-in-Charge in special circumstances.

Grading Requirements for Sub-base Material			
Sieve designation Standard / Alternate (mm.) / inches	Mass Percent Passing Grading		
	A	B	C
60.0(2 ½ inches)	100	-	-
50.0(2 inches)	90-100	100	-
25.0(1 inch)	50-80	55-85	100
9.5(3/8 inch)	-	40-70	50-85
4.75 (No. 4)	35-70	30-60	35-65
2.0 (No. 10)	-	20-50	25-50
0.425 (No. 40)	-	10-30	15-30
0.075 (No. 200)	5-15	5-15	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 sub-grade in the sub-base, the ratio D15 (Sub-base)/D85 (Sub-grade) should be less than 5.

Where D85 & 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 0.075mm (No. 200) sieve shall not be greater than two third of the fraction passing the 0.425mm (No. 40) sieve. The fraction passing the 0.425mm sieve shall have a liquid limit of not greater than 25 and a plasticity index of 6 or less.
- f) If oversize is encountered, screening of material at source shall be done invariably and no handpicking shall be allowed. However handpicking may be allowed by the Engineer-in-Charge if oversize quantity is less than 5% of the total mass.
- g) Sand equivalent for all classes shall be 25min.

21.1.9.6 Schedule of Material Sampling and Testing

Sampling & testing of the materials shall be done as per the following schedule:

- Gradation (AASHTO T-27); 3 samples from the source or one per thousand cubic meters.
- Plasticity index (AASHTO T-89 & T-90); 3 samples from the source plus as desired on the basis of visual inspection.
- CBR (AASHTO T-193); 3 samples from the source plus according to variation in gradation.
- Abrasion (AASHTO T-96); 3 samples from the source or one per 500 cum.
- Max density (AASHTO T-180); one per 1,000 Cu. m.

21.1.9.7 Construction Requirements

a) Spreading

Granular sub-base material 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 sub-base material.

Granular sub-base material shall be spread on approved sub-grade 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.

The aggregates shall be spread and compacted in one or more layers of thickness not exceeding 15 cm, and not less than 7.5 cm. All layers shall be spread and compacted in a similar manner.

Granular sub-base material shall be spread in uniform layers conforming to their transverse and longitudinal requirements. Hauling or placement of material will not be allowed during such weather or such road conditions which may cause cutting or rutting of sub-grade or contamination of sub base material.

b) Compaction Trial

Prior to commencement of granular sub-base operation, Contractor shall construct a trial length, not to exceed, five hundred (500) meters and not less than two hundred (200) meters with the same approved sub-base 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.

In case the required results are not attained then the Contractor with the approval of the Engineer-in-Charge shall change the equipment and/or the procedure to achieve the required results.

c) Compaction

The moisture content of sub-base 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 sub-base 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 super-elevated curves, where the rolling 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 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 specified density.

Any area inaccessible to rolling equipment shall be compacted by means of mechanical tampers, where the thickness in loose layer shall not be more than 10 cm.

If the layer of sub-base material or part thereof does not conform to the required finish, the Contractor shall, at his own expense, rework, water, and re-compact the material before next layer of the pavement structure is constructed.

Immediately prior to the placing of first layer of sub-base course the sub-grade (both under the travel way and the shoulders) shall conform to the required level and shape. Prior to placing the succeeding layer of the material, the top surface of previous layer shall be sufficiently moist to ensure bond between the two layers. The edges or edge slopes shall be bladed or otherwise dressed to conform to the lines and dimensions on the plans.

No material for construction of the sub-base shall be placed until the sub-grade has been approved by the Engineer-in-Charge.

d) Compaction Requirements

The relative compaction of each layer of the compacted sub-base 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 19mm sieve) as directed by the Engineer-in-Charge. Also adjustment of any material retained on 4.75 mm sieve, AASHTO Method T-224 shall be used.

It shall be ensured that same size of sample is placed in oven for moisture determination in case of laboratory density (proctor) and field density. Moisture content for calculation of field density and proctor shall be observed on material passing 4.75 mm sieve. At least 4 density tests shall be carried out for each layer of 400 meters length.

e) Tolerances

The sub-base shall be compacted to the desired level and cross slopes as shown on the drawings. The allowable tolerance shall be +10mm or -20mm for the total thickness of the sub-base and + 0 mm or -25 mm for final level of the sub-base.

21.1.10 AGGREGATE BASE-COURSE

21.1.10.1 General

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

21.1.10.2 Material Requirements

a) Aggregates

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 sub-

stances. 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.

- i) The gradation curve of the material shall be smooth and within the envelope limits' for Grading (A or B) given below:

Sieve designation Standard/ Alternate mm / (inches)	Mass Percent Passing Grading	
	A	B
50.0 (2 inches)	10	100
25.0 (1 inch)	7	75-95
9.5 (3/8 inch)	30-65	40-75
4.75 (No. 4)	25-55	30-60
2.0 (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).

- ii) 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.
- iii) The Coarse aggregate shall have a wear by the Los Angeles Abrasion test (AASHTO T-96) of not more than forty (40); if overlaid by T.S.T and forty five (45) if overlaid by Asphaltic concrete.
- iv) 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.
- v) The sand equivalent determined according to AASHTO T-176 shall not be less than 45 and the material shall have Liquid Limit of not more than twenty five (25) and plasticity Index of not more than (6) as determined by AASHTO T-89 and T-90.
- vi) The material passing the 19 mm sieve shall have a CBR value of a 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.
- vii) Laminated material shall not be allowed.

21.1.10.3 Filler Material

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 tile 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-in-Charge. The material shall be free from organic matter, dirt, shale, clay and clay lumps or other deleterious matter and shall conform to the following requirements.

AASHTO Sieve	Percent Passing
3/8 inch	100
4	85-100
100	10-30
Plasticity Index (AASHTO – T-90)	6 Maximum
Sand Equipment (AASHTO T-176)	30 Maximum

21.1.10.4 Schedule of Material Sampling & Testing

Sampling and testing of the material shall be done as per the following schedule:

- Gradation (AASHTO T.27); 3 per source plus 1 for each 1000 cum.
- Plasticity index (AASHTO T-89 & T-90); 3 per source plus .as desired on the basis of visual inspection.
- CBR (AASHTO T-193); 3 per source plus as required on variation of aggregates.
- Abrasion (AASHTO T-96); 3 per source plus 1 for each 5000 cum.
- Sodium sulphate (AASHTO T-104); 3 per source plus 1 for each 5000 cum.
- Fractured faces; 3 per source plus as per visual inspection.
- Moisture density (AASHTO T-180); 1 for each 1000 cum.

21.1.11.5 Construction Requirements

a) Preparation of Surface for Aggregate Base Course

In case crushed aggregate base is to be laid over prepared sub base course, the sub base course shall not have loose material or moisture in excess to optimum moisture content.

b) Spreading

Aggregate base material shall be deposited on the roadbed in a quantity which will provide the required compacted thickness without resorting to spotting, picking up or otherwise shifting the base material.

Aggregate base material shall be spread on approved sub-base 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.

The aggregates shall be spread and compacted in one or more layers of thickness not exceeding 15 cm, and not less than 7.5 cm. All layers shall be spread and compacted in a similar manner.

Aggregate base material shall be spread in layers conforming to the transverse and longitudinal requirements. Hauling or placement of material will not be allowed during such weather or such road conditions which may cause cutting or rutting of sub-grade or contamination of base material.

Moisture content determination shall conform in all respects to requirements specified in 21.1.10.4(d).

c) Trial Section

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.

d) Compaction

The moisture content of base 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 base 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 super-elevated curves, where the rolling 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 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 specified density. Any area inaccessible to rolling equipment shall be compacted by means of mechanical tampers, where the thickness in loose layer shall not be more than 10 cm.

If the layer of base material, or part thereof does not conform to the required finish, the Contractor shall, at his own expense, rework, water, and re-compact the material before next layer of the pavement structure is constructed.

Immediately prior to the placing of first layer of base course the sub-base top (both under the travel 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 the previous layer shall be sufficiently moist to ensure bond between the two layers. The edges or edge slopes shall be bladed or otherwise dressed to conform to the lines and dimensions on the plans.

No material for construction of the base course shall be placed until the sub-base has been approved by the Engineer-in-Charge.

e) Compaction Requirements

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-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-in-Charge. Also for adjustment of any material retained on 4.75 mm sieve, AASHTO Method T-224 shall be used. Moisture content for calculation of field density shall be observed on material passing 4.75 mm sieve. At least density tests shall be carried out on each layer of 400 meters.

f) Maintaining Base Course

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 by wetting, balding, rolling and addition of lines 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.

g) Tolerances

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 +5mm or -10mm for the total thickness of the base course and + 5mm or 10mm in the final level of the base course.

21.1.10.5 Brick Ballast Sub-base or Base-Course

- a) Where specified the brick ballast of size 1 ½" to 2" (3.75mm – 50mm) made out of first class bricks complying with the requirements of Section 11 – Brickwork shall be used as sub-base & base material for construction of roads.
- b) The brick ballast shall be placed in layer of 6" for thickness as specified. The preparation of sub-grade shall meet the provisions of Section 21.1.9 or as specified. Brick bats shall be raked off the stack with rakes to clear of mud and dust if any. The brick ballast shall be spread evenly over the

prepared surface to the required depth with a finishing material to avoid segregation. Brick ballast shall be carefully laid and packed, bigger size being placed at the bottom to 3" depth unless specified otherwise. After the area shall be grouted with fine sand.

- c) The brick ballast shall be consolidated by dry rolling with 3 ton or light weight power roller and directed by the Engineer-in-Charge,

21.1.11 WATER BOUND MACADAM BASE-COURSE

21.1.11.1 General

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 with the assistance of water, laid on a prepared sub-grade, sub base, or existing pavement in conformity with the lines, grades and. cross-sections shown on the drawings.

21.1.11.2 Material Requirements

a) Coarse Aggregates

Coarse aggregates either crushed or broken stone shall conform to the quality requirements as specified hereunder except that no CBR testing is required. The gradation curve of the coarse aggregates shall be within the envelop limits as follows:

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

Loss Angeles Abrasion Value shall not exceed 45% and Flakiness Index shall not exceed 15%; coefficient of uniformity shall be greater than four (4); 90% of the particles shall have at least 2 faces crushed; soundness test shall not produce loss more than 12% and CBR value of material passing 19 sieve shall not be less than 80%.

b) Fine Aggregates

Fine aggregates (filler material or screenings or murum) shall consist of natural sand or crushed stone screenings free from clay lumps, dirt and other objectionable material. The fine aggregate shall be of the following gradation:

US Standard Sieve Sizes	Percent Passing by weight
9.5mm (3/8 inch)	100
4.35mm (No. 4)	85-100
0.15mm (No. 100)	10-30

The material passing No. 40 sieve shall have Liquid Limit of not more than 25 & Plasticity Index of not more than 6. When more than one layer is required to complete the Macadam course to the thickness shown on the drawings, each layer shall be constructed as prescribed before.

21.1.11.3 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).

21.1.11.4 Binding Material

Binding material to prevent ravelling of water bound macadam shall consist of fine grained material passing 100 percent through 425 micron sieve and possessing Plasticity Index (P.I) 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.

21.1.11.5 Construction Requirements

a) Equipment

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

b) Structure Preparation

Preparation of surface for water bound macadam shall be carried out in the same manner as for aggregate base course Sub-Section 21.1.11.5(a).

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, their inside edges may be trimmed vertical and the included area cleaned of all 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.

c) 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 (2.5) 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 the hauling over a partly completed base be permitted, however dumpers shall be allowed at the construction area where the material will be spread 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 screening, 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.

d) Construction Control Testing

Tests for compliance with the requirements of materials will be as deemed necessary and to the satisfaction of the Engineer-in-Charge.

e) Maintenance

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

21.1.12 CRUSHED STONE SOLING

21.1.12.1 Stones

The stones shall be clean, hard stones, free from decay and weathering. They shall be in block and hammer dressed on all sides. The sizes of the stones unless otherwise specified shall be approximately 22.5 cm. in depth and not less than 15 cm. in any other direction.

21.1.12.2 Preparation of Surface

The stones shall be placed on sub-grade prepared as specified under Sub-section 21.1.9. The sides and bottom of sub-grade shall be brought to the required slope and gradient and shall be compacted to a firm and even surface.

21.1.12.3 Laying of Stone

The depth of stone laid shall be of 22.5 cm. depth unless specified otherwise. Profiles shall be put up by means of pegs and strings or by placing stones, at intervals of not more than 15 meters. The stones shall then be laid closely in position in between the profile and firmly embedded with joints staggered and with exposed faces true to line, gradient and in uniform slope throughout.

Cross bands of approximately 22.5 cm. width through bond stones equal to the full depth shall be provided at an interval of approximately 3 metres centre to centre both longitudinally and transversely.

The interstices between adjacent stones shall be packed with stones, spawls & chips of proper size, well driven in with crow bars to ensure tight packing and complete filling of all interstices. Such filling shall be carried simultaneously with the placing in position of the large stones and shall in no case be permitted to fall behind. Final wedging shall be done with the largest sized chip practicable, each chip being well driven home with a hammer so that no chip is possible of being picked up or removed by hand.

21.1.13 BRICK SOLING

21.1.13.1 General

The brick soling of road shall consist of laying a course of burnt brick over prepared sub-grade and filling the interstices with sand.

21.1.13.2 Materials

a) Bricks

The bricks shall conform to the provisions of Section 11 – brickwork as specified. They shall be well burnt, rather slightly over-burnt without being vitrified. They shall be of uniform colour, regular in shape and size, with sharp and square corners and parallel faces. They must be homogenous in texture and emit a clear ringing sound when struck. They shall be free from flaws and cracks. They shall not absorb more than 1/6th of their weight of water after being soaked for one hour, and shall show no signs of efflorescence on drying. Compressive strength shall not be less than 2000 lbs pounds per square inch or 140.62 Kgs./ Sq. cm.

b) Sand

Sand shall be used for filling joints between the bricks. It shall conform to Specification 11.7.2(ii) – Cement Mortar – Brickworks.

c) Water

Water for mortar shall conform to specification 11.7.2(ii) Cement Mortar – Brickwork.

21.1.13.3 Construction Requirements

a) Preparation of Sub-grade

The sub-grade shall be constructed in accordance with clause 21.1.9 of this Section.

The sub-grade shall have a camber of 1:60 except at curves where requisite super-elevation shall be given.

b) The Construction Procedure

The centre line of the proposed road shall be marked on the sub-grade and necessary level pegs shall be fixed every 25 feet along the sides of the road. Bricks shall be laid on edge 4.5 inches thick. A 3 inches wide and 9 inches deep brick on end edging shall be laid on both sides of the brick on edge soling. A string course of 9 inch brick on edge shall be laid on both sides of the trench as well as in the centre parallel to the centre line of the roads. The bricks shall be laid diagonally towards the centre line of the road between the string courses and to correct levels. Bricks shall be laid by the masons with close fine joints and shall be set properly with wooden mallets. All joints shall be evenly spaced and laid diagonally to the centre line of the road. The direction of the diagonals shall be changed every 25 feet and each section shall be broken by a cross string course 9 inches wide bricks on edge. After the bricks have been laid and approved by the Engineer-in-charge, the joints shall be carefully filled with clean sand.

21.1.14 CRACK – RELIEF LAYER

21.1.14.1 General

The work shall consist of constructing a layer of graded crushed aggregate or asphaltic open-graded plant mix on a prepared soil-cement base course in accordance with these specifications and in conformity with the lines, grades, thicknesses and typical cross sections shown on the Drawings.

21.1.14.2 Material Requirements

a) Aggregates

Material for graded crushed aggregates shall in all respects conform with the requirements specified under 21.1.11 with the following exceptions and supplementary requirements:

- i. The portion of the aggregate 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).
- ii. Crushed aggregates shall consist of particles with not less than Ninety (90) percent of the portion retained on the 4.75 mm. (No.4) sieve having at least two fractured faces.

Aggregates for the asphaltic open-graded plant mix shall conform to the requirements of 21.1.12 with the following exceptions:

Fine aggregates and mineral filler will be required. Sand equivalent and plasticity requirements are not applicable.

b) Asphaltic Material

Asphaltic binder shall be asphalt cement, 60-70 penetration grade, meeting the requirements of AASHTO M-20.

c) Asphaltic Open-Graded Mixture

The composition of the asphaltic open-graded crack-relief layer shall meet the following criteria:

AGGREGATE GRADING REQUIREMENTS		
mm	Sieve Designation inch	Percent Passing by Weight
50	2	100
37.5	1.1/2	75-90
19	¾	50-70
4.75	No. 4	8-20
0.15	No.100	0-5
Asphalt Cement content of total Mix		2-3% by weight
Mixing Time		30 seconds (maximum)
Mix Design		Within Master Range Gradation

The exact percentage of asphalt cement content shall be such that at least Ninety five (95) percent coating of aggregates will be achieved when tested in accordance with AASHTO T-195.

21.1.14.3 Construction Requirements

Prior to construction of the crack-relief layer (CRL) the completed base course shall be duly accepted by the Engineer-in-Charge.

21.1.14.4 Graded Crushed Aggregate

Construction of this layer shall conform in all respects to the requirements specified under Item 21.1.11.

A Asphaltic Open-Graded CRL

Construction of this layer shall conform in all respects to the requirements specified under Item 21.1.23 except as provided below:

- a) Compaction shall be accomplished by ten (10) Ton steel Wheeled tandem rollers. A maximum of three complete coverage, or as otherwise directed by the Engineer-in-Charge shall be

sufficient. No density test will be required, however the compaction shall be achieved in the same manner as displayed in the total test and to satisfaction of the Engineer-in-Charge.

- b) The consistency and temperature of the mix shall be such controlled that it does not squeeze out or move under the pressure of compacting roller. For this purpose, trial reaches shall be prepared by the contractor to fix the above parameters.

In order to ensure the stability of CRL before the placement of any subsequent layer or opening of a layer to traffic, a priming time of 4 days in hot weather will be allowed. This time may be reduced to two days where the lower temperature allows.

- c) All traffic shall be kept off this layer until a subsequent layer has been placed on it. Any damage caused by traffic moving directly on the crack-relief layer shall be the responsibility of the Contractor and all necessary repair work thereto shall be at the Contractor's expense.

21.1.15 GEOTEXTILES

21.1.15.1 General

The work covered by this section shall consist in furnishing all material, labour, equipment and placing of Geo-textiles on prepared surfaces complete in accordance with the specifications for the work items involved, in thicknesses and to the dimensions shown on the typical cross-section of applicable drawings or as directed by the Engineer-in-Charge.

21.1.15.2 Geotextile Functions

Where indicated on the drawings or directed by the Engineer-in-Charge, Geotextile will be placed to perform one or more of the following functions.

- One road foundation for the purpose of separation between road fill material and soft underlying soils in order to eliminate the need for removal of poor subsoil material and quick and effective drainage of soil-fill interface.
- For subgrade stabilization and increasing soil shear strength by providing bonding mechanism of the Geotextile-soil system.
- As a filter for all drainage systems where a danger of clogging by fine particle of adjacent soil is possible. The Geotextile will retain the particles from passing whilst allowing the seepage water to pass through.
- As a filter element for all bodies of water where the soil can be eroded by current, wave action or changing water levels.
- For permanent protection of synthetic sealing systems (Geo-membrane) against mechanical damage during installation and after completion of construction.

21.1.15.3 Material Requirements

1. Composition and Environmental Behaviour

The raw material of Geotextile shall be Ultra Violet stabilized polypropylene. The fibers shall consist of continuous filaments of approximately 40 micron diameter and mechanically bonded by needling. The Geotextile material shall be resistant to acid and alkaline media in the pH range 2 to 13, resistant to lime, cement and concrete, resistant to all naturally occurring bacteria and fungi. A prolonged outside exposure of several months shall have no effect on the properties of Geotextile.

2. Mechanical and Hydraulic Properties

- To ensure free drainage, the geotextile shall have high water permeability.
- Geotextile shall offer high retention capability for almost all types of soils.

- The geotextile shall have optimum stress-strain behaviour even with low unit weight for high resistance against installation damage.

21.1.16.4 Construction Requirements

- a. Preparation
The surface shall be fairly levelled before placement of Geotextile. It is to be ensured that there are no protruding stones which may damage the geotextile fabric.
- b. Geotextile Placement
The Geotextile shall be rolled out directly on top of the prepared surface in a manner as recommended by the manufacturer. It shall be over lapped at the edges as shown on the drawings or as recommended by the manufacturer.
- c. Placement of Fill
The first layer of fill material shall be applied by overhead placement. Traffic on the geotextile itself shall be avoided. Necessary precautions shall be observed to ensure that geotextile shall not be damaged during placement.
- d. Spreading
Spreading of fill material shall be done with suitable equipment and procedure ensuring that geotextile must not be damaged by high axle load stresses of spreading equipment travelling on sharp fill over the geotextile.
- e. Compacting
The compacting method (Static/Dynamic) shall be suited to sub-grade/fill material.
- f. Jointing of Geotextile Panels
A tension joint shall be achieved by overlapping, welding or sewing as shown on drawings or approved by the Engineer-in-Charge.
- g. Overlapping
Overlapping width shall not be less 30 cm on even surface and 50 cm on uneven surface. In order to avoid displacing the geotextile during backfill over end panel joints, the connecting panel must be placed underneath the end of the previously rolled out geotextile.
- h. Welding
Welding width shall not be less than 10 cm. A wide pattern gas torch shall be used at a low temperature and about 20 cm from the geotextile. The welded geotextile section shall be continuously pressed down by walking on it during placement.
- i. Sewing
The stitching method shall be single thread, double thread or butterfly type suitable to geotextile thread type and strength. The thread shall be sufficiently tightened and stitch density shall be three to six stitches per inch.

21.1.15.4 Geotextile Function for Repaving

This section deals geotextiles placed between old pavement and new asphalt overlay, alongwith suitable tack coat of bitumen. Where indicated on drawings or directed by the Engineer-in-Charge, geotextile will be placed to perform one or more of the following functions:

- To ensure proper adhesion between old pavement and new asphalt overlay & thus reducing the overall flexural tensile stresses and increasing life of road surface.
 - As a cut off layer for the prevention of propagation of cracks in the pavement.
 - As water barrier, even under high pressure to stop reflective cracking in the pavements.
1. Construction Requirements
 - Removal of dirt, dust and vegetation from wearing surface and cracks.
 - Filling potholes and larger cracks (>5mm) with hot mix or an adequate filler.
 - Removal of sharp or craggy edges on surface.

- On badly damaged roads, a level course of approx. 1.5 cm shall be laid to avoid the labour intensive and time consuming operation of crack filling.
2. Applying the tack coat
- Depending on the condition of the old surface, a calculated amount of tack coat (Q_{ef}) of the approx. 1.1 kg/m² active binder is to be sprayed evenly on the prepared surface before laying geotextile, making sure that:-
- The bitumen is applied beyond the width of the geotextile by about 5 cm on either side.
 - The spraying temperature for pure bitumen is kept between 150°C and 170°C to achieve a coating as even as possible.
 - When using bitumen emulsion, the coating amount is adjusted to contain the required average amount of bitumen.
 - The coating is only applied to areas where the paving felt is to be laid.
 - No additional pre-spray agent is applied on top of the paving felt.
 - Where only sections for the road are covered with the paving felts, their surfaces must be gritted.
3. Laying Geotextile
- Geotextile shall be laid by hand or machine taking into account that:
- When using pure bitumen as tack coat, Geotextile may be laid immediately after coating.
 - When using bitumen emulsion, Geotextile shall not be laid until the emulsion has cured.
 - Wrinkles shall be avoided.
 - Edges lengthways and across overlap by 5-10 cm, an additional pure bitumen binder of 0.9 kg/m² shall be applied on the overlapping seams.
 - Transverse overlapping is to be carried out with reference to the direction in which the asphalt finisher will proceed i.e. under the previous one so that the felt does not shift out of place when the asphalt concrete is applied.
 - When one half of the road is made (leaving the other open to traffic), at least 25 cm of the lengthways felt edge shall remain uncovered to allow overlapping when laying the other half of the road.
 - During short time stoppages of construction work, the road under construction shall be opened only to slow traffic without detriment to Geotextile.
 - Rain water on the Geotextile surface shall be allowed to evaporate before applying a top layer.
4. Applying the Asphalt Concrete Surface
- The asphalt concrete surfacing shall be applied immediately after laying Geotextile preferably by crawler type finisher, taking the following points into consideration.
- The material mix shall have a temperature between 145°C and 165°C.
 - To avoid types of the finisher or truck sticking to the felt (which can happen in hot climates or where too much tack coat has been applied), some of the mix can be spread manually in the pathway of the vehicles.

21.1.15.5 Geotextile testing

Geotextile testing shall be in accordance with the following standard test method.

Weight	ASTM D-3776
Thickness	ISO 9863
CBR Puncture Resistance Test	BS6906/4
Strip Tensile test	ASTM D-4595

Grab Tensile Test	ASTM D-1682
Tear strength test	ASTM D-1117
Penetration resistance test (drop test)	NT Build 243
Vertical permeability	BS 6906/3
Pore size	E DIN 60500/6

Based on the required functions and the type of stresses, the contractor shall propose the type of geotextile. The contractor shall furnish technical literature and manufacturer's certificates of guarantee for the type of geotextile material for approval of Engineer –in-charge prior to delivering the material to the site. The certificate shall note compliance to the specifications and shall state the result of the test performed on the material, as required by the specifications.

21.1.16 INTERLOCKING CONCRETE PAVING BLOCKS

21.1.16.1 General

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

21.1.16.2 Material Requirements

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

1. Binders and Binder Constituents

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

Section	Description	Section	Standard
21.2	Ordinary Portland Cement	21.3	BS 12
21.4	Portland Blast-furnace Cement	21.5	BS 146: Part 2
21.6	Portland Pulverized Fuel ash Cement	21.7	BS 6588
21.8	Pulverized fuel ash	21.9	BS 3892: Part 1
21.10	Ground granulated blast-furnace slag	21.11	BS 6699

Where pulverized fuel ash is used, the proportions and properties of the combination with Portland cement shall comply with as BS 6588. Where ground granulated blast furnace slag is used, the proportions and properties of the combination with Portland Cement shall comply with BS 146: Part 2.

Aggregates

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

Section	Description	Section	Standard
21.2	Natural Aggregates (Crushed or Uncrushed)	21.4	BS : 882 : 1983 (except grading requirement in clause 5)
21.5	Air Cooled blast-furnace slag	21.6	BS 1047 : 1083 (except grading requirement in 4.8)
21.7	PULVERIZED FUEL ASH Ground granulated blast-furnace slag	21.8	BS 3892 : Part-1 or Part-2 BS 6699

a) Acid Soluble Material (Fine Aggregate)

When tested as described in BS 812 : Part 119, the fine aggregate (material passing a 5mm sieve complying with BS 410) shall contain not more than 25% by mass of acid soluble material either in the fraction retained on or in the fraction passing, a 600µm sieve.

b) Water

The water shall be of drinking quality or in accordance with the provisions in Sub-Section 5.3.1.6 under Plain & Reinforced Concrete.

c) Admixtures and Pigments

Proprietary accelerating, retarding and water reducing agents shall comply with Sub-Section 5.3.1.7 under Plain & Reinforced Concrete. Pigments shall comply with BS 1014.

Calcium chloride shall comply with BS 3587.

d) Finishes

The finish should be agreed between the manufacturer and the Engineer-in-Charge. Concrete described as "natural colour" shall contain no pigment.

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

e) Binder Content

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

21.1.17.3 Sizes and Tolerances

1. Sizes

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

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

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

2. Tolerances

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

Length	$\pm 2\text{mm}$
Width	$\pm 2\text{mm}$
Thickness	$\pm 3\text{mm}$

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

21.1.17.4 Compressive Strength

The compressive strength of paving blocks shall be not less than 49 N/mm^2 (7000 psi) and the crushing strength of any individual block shall be not less than 40 N/mm^2 (6000 psi).

21.1.17.5 Sampling

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

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

21.1.17.6 Marking

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

- a) The name, trade mark or other means of identification of the manufacturer.
- b) The number and date of this British Standard, i.e. BS 6717: Part 1 : 1986*; or latest revision.

21.1.17.7 Construction Requirements

1. Laying the Paving Blocks

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

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

2. Tolerance

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

Payment for each of the above item shall be made under the relative item of work. The total area will thereby be divided with nylon strings into sectors of not more than 1.5 square meters. This shall be done to control the alignment of paving blocks and to avoid multiplication of deviation in sizes of paving blocks.

21.1.18 ASPHALTIC MATERIALS

21.1.18.1 Asphalt Cement

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

Asphalt Cement shall be classified by penetration and when tested in accordance with the standard methods of tests of the AASHTO, the grades of asphalts shall conform to the requirements set forth in Table 21(a) and 21(b). The grade of asphalt to be used shall be in accordance with these specifications or the Special Provisions or as directed by the Engineer-in-Charge.

21.1.18.2 Environmental Factors

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

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

SELECTING ASPHALT GRADE

Temperature Condition	Asphalt Grade ±
Cold, mean annual air temperature ≤ 7°C (45°F)	AC-10, AR-4000, 80 / 100 pen.
Warm, mean annual air temperature between 7°C (45°F) & 24°C (75°F)	AC-20, AR-8000, 60 / 70 pen.
Hot, mean annual air temperature ≥ and 24°C (75°F)	AC-40, AR-8000, 40 / 50 pen.

*Both medium setting (MS) and slow setting (SS) emulsified asphalts are used in emulsified asphalt base mixes. They can be either of two types; cationic (ASTM D-2397 or AASHTO M-208) or anionic (ASTM D-977 or AASHTO M-140). Selecting one of the two shall depends on the type of aggregate used for better affinity.

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

21.1.18.3 Cut-Back Asphalt

Liquid asphalts (cut-back) shall consist of materials conforming to the following classifications. When tested in accordance with the standard methods of tests of the AASHTO, the grades of liquid asphalt shall conform to the requirements specified in the Tables 21(c) and 21(d). Medium curing products designated by letters MC, shall consist of asphalt cement fluxed or blended with a kerosene solvent. Rapid curing products designated by the letters RC, shall consist of asphalt cement with a penetration of approximately 80 to 100, fluxed or blended with a naphtha solvent.

21.1.18.4 Emulsified Asphalt

Asphaltic emulsions shall be composed of a bituminous base uniformly emulsified with water and an emulsifying or stabilizing agent. They shall be classified according to use as Rapid Setting or Slow Setting, and shall conform to the requirements specified in Table 21(e).

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

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

**TABLE 21(a)
APPLICATION TEMPERATURE RANGE 'C'**

Description	Spray	Mix
Asphalt Cement (All grades)	160 (max)	As required to achieve viscosity of 75-150 secs. Saybolt-Furol or as required to achieve a Kinematic Viscosity of 150-300 centistokes.
Cut-back or Emulsified Asphalts		
MC-70, RC-70	27-65	27-65
MC-250	38-93	38-93
RC-250	38-79	27-65
MC-800	85-127	71-99
RC-800	71-107	57-85
SS-1, SS-1H	24-55	-
RS-1	24-55	-
RS-2	44-70	-

**TABLE 21 (b)
REQUIREMENTS FOR ASPHALT CEMENT (AASHTO M-20)**

Description	Penetration Grade							
	40-50		60-70		80-100		120-150	
	Min	Max	Min	Max	Min	Max	Min	Max
Penetration at 77°F (25°C) 100g 5sec.	40	50	60	70	85	100	120	150
Flash point, Cleveland Open Cup, 0°F (0°C)	150 (232)	- -	450 (232)	- -	450 (232)	- -	425 (218)	- -
Ductility at 77°F (25°C) 5 cm per min. cm.	99	-	99	-	99	-	99	-
Solubility in trichloroethylene percent	99	-	99	-	99	-	99	-
Thin-film oven test, 1/8 inch (3.2mm), 325°F, (163°C), 5 Hrs. Loss on heating, percent	-	0.8	-	0.8	-	1.0	-	1.3
Penetration of residue, percent of original	58	-	54	-	50	-	46	-
Ductility of residue at 77°F (25°C), 5 cm. per min. cm.	-	-	50	-	75	-	100	-

TABLE 21 (c)
REQUIREMENTS FOR MEDIUM-CURING TYPE ASPHALT (AASHTO M-82)

Description	MC-70		MC-250		MC-800	
	Min	Max	Min	Max	Min	Max
Water percent	-	0.2	-	0.2	-	0.2
Flash point (tag. open cup) C	38	-	66	-	66	-
Kinematic Viscosity at 60°C (140°F) (See Note 1) Centistokes	70	140	250	500	800	1600
Distillation test: Distillate, percentage by volume of total distillate to 360°C (680°F)						
to 225°C (437°F)	0	20	0	10	-	-
Description	MC-70		MC-250		MC-800	
	Min	Max	Min	Max	Min	Max
to 260°C (500°F)	20	60	15	55	0	35
to 315°C (600°F)	65	90	60	87	45	80
Residue from distillation to 360°C (680°F) volume percentage of Sample by difference	55	-	67	-	75	-
Tests on residue from distillation: Penetration, 100 g., 5 sec., at 25°C (77°F)	120	250	120	250	120	250
Ductility, 5 cm/min.cm.(see note 2)	100	-	100	-	100	-
Solubility in Trichloroethylene percent	99	-	99	0	99	-

MC-800

Note-1: As an alternative, SayboltFurol Viscosities may be specified as follows:

- Grade MC-70 Furol viscosity at 50°C (122°F) – 60 to 120 sec.
- Grade MC-250 Furol viscosity at 60°C (140°F) – 125 to 250 sec.
- Grade MC-800 Furol viscosity at 82.2°C (180°F) – 100 to 200 sec.

Note-2: If penetration of residue is more than 200 and its ductility at 25°C (77°F) is less than 100 cm, the material will be acceptable if its ductility at 15.5°C (60°F) is more than 100 cm.

TABLE 21 (d)
REQUIREMENTS FOR RAPID-CURING TYPE ASPHALT (AASHTO M-81)

	RC-70		RC-250		RC-800	
	Min	Max	Min	Max	Min	Max
Water percent	-	0.2	-	0.2	-	0.2
Flash point (tag. open cup) °C	-	-	27	-	27	-
Kinematic Viscosity at 60°C (140°F)(See Note 1) centistokes	70	140	250	500	800	1600
Distillation test:						
Distillate, percentage by volume of total distillate to 360°C (680°F)						
to 190°C (374°F)	10	-	-	-	-	-
to 225°C (437°F)	50	-	35	-	15	-
to 260°C (500°F)	70	-	60	-	45	-
to 315°C (600°F)	85	-	80	-	75	-
Residue from distillation to 360°C(680°F)volume percentage of Sample by difference	55	-	65	-	75	-
Tests on residue from distillation:						
Penetration, 100 g. 5 sec. at25°C (77°F)	80	120	80	120	80	120
Ductility, 5 cm/min. cm. of 25°C (77°C) cm.	100	100	-	100	-	-
Solubility in Trichloroethylene percent	99	-	99	-	99	-

Note-1: As an alternative, SayboltFurol Viscosities may be specified as follows:
 Grade MC-70 Furol viscosity at 50°C (122°F) – 60 to 120 sec.
 Grade MC-250 Furol viscosity at 60°C (140°F) – 125 to 250 sec.
 Grade MC-800 Furol viscosity at 82.2°C (180°F) – 100 to 200 sec.

TABLE 21 (e)
REQUIREMENTS FOR EMULSIFIED ASPHALT (AASHTO M-140)

TYPE.....	Rapid – Setting				Slow - Setting			
	RS – 1		RS – 2		SS – 1		SS -1h	
	Min	Mix	Min	Mix	Min	Max	Min	Max

TEST OF EMULSIONS								
Viscosity, saybolt furol at 77°F (50°C), sec.	10	100	-	-	20	100	20	100
Viscosity, saybolt furol at 122°F (50°C), sec.	-	-	75	400	-	-	-	-
Settlement 5 days, percent(a)	-	5	-	5	-	5	-	5
Storage stability test, one day(b)	-	1	-	1	-	1	-	1
De-mulsibility C 35 ml 0.02 NCaCL2 percent	60	-	60	-	-	-	-	-
Cement mixing test, percent	-	-	-	-	-	2.0	-	2.0
Sieve test, percent	-	0.1	-	0.1	-	0.1	-	0.1
Residue by distillation, percent	55	-	63	-	57	-	57	-
Test on residue from distillation test penetration 77°F (25°C) 100g. 5 sec.	100	200	100	200	100	200	40	90
Ductility, 77°F (25°C), 5 cm/mim.cm.	40	-	40	-	40	-	40	-
Solubility in Trichloroethylene percent	97.5	-	97.5	-	97.5	-	97.5	-
Suggested Uses	Surface treatment & penetration macadam tack coat		Surface treatment & penetration macadam.		Plant or road mixture with graded and fine aggregates a substantial quantity of which passes a No.8 (2.3mm) sieve & a portion of which may pass No.200 (0.75mm) sieve: slurry seal treatment.			

NOTES:

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

21.1.19 BITUMINOUS SURFACE TREATMENT

21.1.19.1 General

This work shall consist of furnishing and application of three courses of asphaltic material of the specified type and grade with one, two or three covers of aggregates in accordance with these specifications to the width shown on the Drawings or as directed by the Engineer-in-Charge.

21.1.19.2 Material Requirements

a) Aggregate

Aggregate shall consist of clean, dry, hard, tough, angular, sound crushed stone, or crushed gravel of uniform quality, free from dust, clay, and other deleterious materials and from excess of flat or laminated pieces. All aggregate materials shall have a percentage of wear by the Los Angeles Abrasion test (AASHTO T-96) of not more than 40 percent. When subjected to 5 cycles of sodium sulphate soundness testing as determined by AASHTO T-104, it shall have a weight loss not greater than 10 percent. The moisture content in the aggregate applied directly to the surface of the bituminous material shall not exceed 3 percent by weight plus one half ½ the water absorption of the aggregate at the time of delivery to the project.

The portion of aggregate retained on the 9.5mm (3/8 inch) sieve shall not contain more than 15 percent of particles by weight so 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 18mm and 12mm and 30(max) for nominal 9 mm. size The percentage composition by weight of aggregate shall conform to the following gradations:

US Standard Sieve	Percentage Passing by Weight			
	Size No.1(18mm)	Size No.2(12mm)	Size No.3(9mm)	Size No.4(6mm)
1" (25.00 mm)	100	--	--	–
¾" (19.00 mm)	90 – 100	100	--	–
½" (12.50 mm)	20 – 55	90 – 100	100	–
3/8" (09.50 mm)	0 – 15	40-70	85-100	100
No. 4 (04.75 mm)	0 – 5	0 – 15	10-30	85 – 100
No. 8 (02.38 mm)	--	0 – 5	0 – 10	10 – 40
No. 16 (01.18 mm)	--	0	0-5	0 – 10
No. 200 (0.075 mm)	--	--	---	–

b) Asphaltic Material

The asphaltic material shall conform to the requirements of AASHTO M-20, M-81, M-82 and M-140. The type shall be the following or as instructed by the Engineer-in-Charge.

Triple surface treatment: AC 85-100, RC-70, RS-1 or RS-2.

21.1.19.3 Construction Requirements

Surface treatment shall be applied when the weather is warm and dry, and the road surface is clean and dry. Spraying shall not be done unless the road temperature has been above 20 degree Centigrade for at least one hour prior to the commencement of spraying operations, and the temperature shall not be less than 20 degree centigrade during spraying. Prior to applying the asphaltic material, dirt and other objectionable materials shall be removed from the surface. If so directed by the Engineer-in-Charge, the surface shall be cleaned by power booming until all loose and foreign materials are removed.

a) Equipment

The liquid asphaltic material shall be sprayed by means of a pressure distributor of not less than 240 gallon capacity, mounted on pneumatic tyres of such width and number that the load produced on the road surface will not exceed 560 lb. per inch width of tyre. It shall be of recognized manufacture.

The tank shall have a heating device able to heat a complete charge of asphaltic liquid upto 180 degree Centigrade. The heating device shall be such that overheating will not occur. Consequently, the flames must not touch directly on the casting of the tank containing the asphaltic liquid or gases there from. 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 so insulated that the drop in temperature when the tank is full and not being heated, will be less than 2°C/hour. A thermometer shall be fixed to the tank to enable continuous control of 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 quantity. The pipes for filling the tank shall be furnished with an easily interchangeable filter.

The distributor shall be such that the spray width of the asphaltic liquid can be varied in steps of maximum (4 inch) to a total width of 13 ft (4 m). The spraying bar shall have nozzles from which the liquid is sprayed in fan shaped pattern on the road surface with uniform distribution over the total spraying width. .

The distributor shall have a pump driven by a separate motor for dosing the liquid 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 liters per minute. At the suction side the pump shall have an easily exchangeable filter. 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 10 square feet does not exceed 10%. The distributor shall also be equipped with a device for hand spraying of the bituminous liquid.

b) **Application of Asphaltic Materials**

Asphalt cement, liquid asphalt and emulsified asphalt shall be applied by means of pressure distributor at the temperature specified for the type and grade of asphalt being used. The rates of application shall be within the range given in Table 21(f) However, the exact rate shall be determined by the Engineer-in-Charge.

The spread of bituminous materials shall be at least 10cm wider than the width 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 be less 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, 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 bituminous 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 bituminous material thereby causing uneven coverage. The angle of the spray nozzles and the height of 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.

c) **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. The truck carrying the aggregate shall move back-ward as it spreads the 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 20-minutes after spraying. Immediately after spreading of the aggregate, the treated surface shall be rolled with a self-propelled pneumatic-tyred roller having a minimum contact pressure of 40 psi (2.8 kg/sq.cm). A steel-wheeled roller weighing between 6 to 8 tons should be used as a second roller. Rolling shall continue until a smooth, thoroughly compacted surface is obtained. Procedures of starting, stopping or turning of any piece of equipment which results in displacement of cover material or damage to seal courses is prohibited.

Any place where binder shows on the surface shall be covered with additional aggregate and further rolled and broom-dragged until an even surface results, and does not adhere to wheels of vehicles. Over lapping the application of cover material shall be avoided and all spillage shall be removed from surface.

The quantity of aggregate to be applied shall be within the ranges specified in Table 21(f) however, the exact rate shall be determined by the Engineer-in-Charge.

TABLE 21 (f)

Bituminous Surface Treatment		Aggregate		Bituminous Material	
Type	Application	Size No.	Quantity KG/Sq.M	Quantity Litre/Sq.M	Type
SINGLE	Single	2	12.5	1.19	(a)
				1.63	(b)
DOUBLE	First	1	24	1.90	(a)
				2.14	(b)
	Second	3	12.5	1.19	(a)
				1.63	(b)
TRIPPLE	First	1	24	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)

NOTE: Bituminous material types are (a) asphalt cement, (b) cut-back (c) asphalt cement or cut-back.

21.1.19.4 Maintenance of Traffic

Detouring of highway traffic for this work will not be provided for or permitted, except when authorized by, the Engineer-in-Charge. 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 sufficient number of pilot cars to control traffic through the bituminous sealing operations when so directed by the Engineer-in-Charge. 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" on both English and Urdu. 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 be moved forward with the flagman as the work progresses.

No separate payment shall be made for conformance to this paragraph all items being considered subsidiary to all of the items in the CSR items.

21.1.19.5 Working Period

All work shall be so conducted that the work of applying asphalt and aggregate and of all rolling shall be completed during the time from sunrise to sunset and under favourable weather conditions determined by the Engineer-in-Charge.

21.1.19.6 Maintenance of completed work

When directed by the Engineer-in-Charge, the Contractor will be required to add bituminous material or aggregate or both to portion of 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".

21.1.19.7 Opening to 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 windblown contamination shall be dusted with crusher waste. After 2-3 days under traffic, excess stone will be removed by brushing.

21.1.19.8 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 6mm. chipping will be applied. After stabilizing of pad coat under traffic, the appropriate surface dressing will be applied.

21.1.20 BITUMINOUS PRIME COAT

21.1.20.1 General

This work shall consist of furnishing all plant, labour, equipment, material and performing all operations in applying a liquid asphalt prime coat on a previously prepared and untreated earth sub grade, water-bound base course, top of road way shoulders, (and as otherwise shown on the plans) In accordance with the specifications and in conformity with the lines shown on- the drawings.

21.1.20.2 Material Requirements

Asphaltic material shall be either cutback or Emulsified Asphalt, whichever is specified.

21.1.20.3 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 15°C unless otherwise directed by the Engineer-in-Charge. 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 this Sub-Section 21.1.20.3. All expansion joints shall be cleaned and filled with bituminous material as directed by the Engineer-in-Charge. Area to be primed will be classified as under:

- i) The top of earth surface or water bound base courses from a point twenty (20) centimetres outside the edge of the pavement line to 20 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 of sub-grade 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-in-Charge.

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.

21.1.20.4 Equipment

The tank for the heating of asphalt liquid shall have a heating device able to heat a complete charge of asphaltic liquid up to one hundred eighty (180) degree centigrade. The heating device shall be so that overheating shall not occur. The flames must not touch directly the tank containing the asphalt liquid or gases there from. The liquid shall be circulated or stirred during the heating. The tank shall be insulated in such a way that after the heating is stopped the drop in temperature of the asphalt within the tank will be less than two (2) degree centigrade per hour. In order to control the temperature of the liquid a thermometer shall be installed. The tank shall be furnished with a device that indicates the contents. The pipes for filling the tank shall be furnished with an easily inter-changeable filter.

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 distributor shall be able to vary the spray width of the asphaltic liquid in steps of maximum 10 cm, to a total width to four (4) meters. 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 be equipped with a device for hand spraying of the bituminous liquid.

All equipment shall be subject to the approval of the Engineer-in-Charge. 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 distributor. The pump shall be furnished with an indicator showing the performance in litres/min. At the suction side the pump shall have a filter easily exchangeable. The thermometer shall be fixed which indicates the temperature of the liquid immediately before it leaves the spraying bar.

The distributor shall be furnished with the Tachometer indicating the speed in meter/min. The Tachometer shall be visible from the driver seat. The function of the distributor shall be equipped with a device for the hand spraying of the bituminous liquid to cover any irregular area or covering the area improperly sprayed.

Application of Asphaltic Material

Immediately before applying prime coat, the full area of surface to be treated shall be free from ruts, corrugations, loose materials and other irregularities.

Prime coat shall be applied on a dry surface, however the surface may be reasonably moist when emulsified asphalt is used. The application shall not be done when the weather is foggy or rainy,

or when the atmospheric temperature is below fifteen (15) degree centigrade unless otherwise directed by the Engineer-in-Charge. Prior to the application of the prime coat the surface shall be cleaned by means of approved mechanical sweepers or blowers and/or hand brooms, until it is free from dust and loose material as far as practicable. No traffic shall be permitted on the surface after it has been prepared to receive the bituminous material. The bridge decks and concrete pavements surfaces shall also be cleaned of all loose materials. All expansion joints shall be cleaned and filled with bituminous material as directed by the Engineer-in-Charge. Areas to be primed shall be:

- i) The top of earth surface or water bound base courses from a point twenty (20) centimeters outside the edge of the pavement either side of the roadway.
- ii) The top of shoulders from the intersection of embankment slope and top of sub-grade 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-in-Charge.

The rate of application of asphaltic material (cut back/emulsified) shall be according to the following rates or as approved by the Engineer-in-Charge.

Sr. No.	Type of Surface	Liters/ Sq. M.	
		Minimum	Maximum
1.	Earth surface, shoulders Water Bound base courses	0.65	1.75
2.	Bridge, Wearing Surfaces, Concrete Pavement	0.15	0.4

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 wheel of passing vehicles. The contractor shall maintain the prime coat until the next course is applied. Care shall be taken that the application of bituminous material is not in excess of the specified amounts any excess shall be blotted with sand or shall be similarly treated. All area 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 a 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 previously covered until it has dried and is ready for traffic.

21.1.21 SURFACE DRESSING ON OLD SURFACE WITH HOT BITUMEN (ONECOAT)

21.1.21.1 General

This treatment consists of cleaning old painted surface and applying a coat of hot bitumen on the prepared base, blinding with stone chippings and consolidation with road roller.

21.1.21.2 Materials

The aggregates & asphalt materials unless otherwise specified shall conform to the provisions of Clause 21.1.19.2.

21.1.21.3 Preparation

Repairs: Pot holes or patches and ruts in the surface course which is to be surface treated, shall be repaired by removal of all loose and defective material by cutting in rectangular patches and replacement with suitable material.

For the purpose of repairs the area of pot holes shall be taken upto 0.75sqm and depth upto 5 cm. All pot holes, patches and ruts upto 2. cm. deep shall be repaired and brought to level with premix and properly consolidated while those of depths greater than 2.5 cm shall be repaired with similar specifications as adopted originally.

Cleaning:

Prior to the application of the surface dressing all dust, dirt, caked mud, animal dung, loose and foreign material etc. shall be removed 30 cm on either side, beyond the full width to be treated, by means of mechanical sweepers and blowers, if available or otherwise with wire brushes, small picks, brooms etc. The material so removed shall be disposed off as directed by the Engineer-in-Charge.

For a water bound macadam surface, the interstices between the road metal shall be exposed up to a depth of about 10mm by means of wire brushes. The surface shall then be brushed with soft brooms to remove all loose aggregate. Finally the traces of fine dust which get accumulated while brushing shall be thoroughly removed from the surface by blowing with gunny bags.

The prepared surface shall be closed to traffic and maintained fully clean till the binder is applied.

21.1.21.4 Construction Requirements

The construction for dressing shall be carried out complying with the provision of clause 21.1.19.3.

21.1.22 BITUMINOUS TACK COAT

21.1.22.1 General

The work covered by this section shall consist of furnishing all plant, labour equipment applying asphaltic material on a previously prepared asphaltic layer in addition to performing all operation in connection with the application of a bituminous tack coat, complete as shown on the typical cross-sections of applicable drawings.

21.1.22.2 Material Requirements

Asphaltic material shall be either emulsified asphalt, or cut back asphalt as specified.

21.1.22.3 Construction Requirements

a) Equipment

Equipment shall conform in all respect to the provision under Item 21.1.20.4 and shall be subject to the approval of the Engineer-in-Charge.

b) Application of Asphaltic Material

Immediately before applying the tack coat, all loose material, dirt or other objectionable material, shall be removed from the surface to be treated as directed by the Engineer-in-Charge. The tack coat shall be, applied only when the surface is dry, however for emulsified asphalt, application may be made on a reasonable moist surface. Application of tack coat shall be avoided in case of foggy or rainy weather or at temperatures below 15°C. Tack coat will not be applied until the surface has been inspected and approved by the Engineer-in-Charge.

Asphaltic material shall be applied at the specified temperature for the particular material being used. Rates of application of cut back or emulsified asphalt shall be within 0.2-0.7 litres per square meter. The exact rate shall be specified by the Engineer-in-Charge.

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

Where no convenient detour is available for traffic, operations shall be confined to one-half the roadway width at a time. The Contractor shall provide proper traffic control so that vehicles may proceed without damage covered by previous application until the surface previously covered has dried and is ready for paving.

Traffic shall be kept off the tack coat at all times. The tack coat shall be sprayed only so far in advance of the surface course as will permit it to dry to a "tacky" condition. The Contractor shall maintain the tack coat until the next course has been placed. Any area that has become fouled, by traffic or otherwise, shall be cleaned by Contractor at his own cost before the next course is applied.

21.1.23 ASPHALTIC CONCRETE ROAD MIX

21.1.23.1 General

This work shall consist of furnishing of aggregates and asphalt binder plant, labour, equipment and performing all operations in connection with the construction of and asphaltic concrete road mix on a previously constructed and accepted sub-grade, sub-base or base course, and in accordance with this Section of the Specification, the drawings and the directions of the Engineer-in-Charge.

21.1.23.2 Material Requirements

- a) Unless otherwise specified or directed the materials for asphalt concrete mix shall comply with the followings specifications.
- b) Mineral Aggregates

Mineral aggregates for bituminous concrete shall consist of coarse aggregate, all conforming with the following requirements:

Course aggregate which is the material retained on No.4 sieve shall consist of crushed rock, crushed gravel or a mixture of crushed rock and crushed gravel. The aggregate shall not contain more than 8% by weight of flat and elongated particles. Ratio of maximum to minimum dimensions of particles shall not exceed 5:1. At least (90) percent by weight shall have two or more fractured faces.

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

When the combined grading of the coarse and fine aggregates is deficient in material passing No. 200 sieve, additional filler material shall be added. The filler material shall consist of finely divided rock dust, hydrated lime, hydraulic cement or other suitable mineral matter. At the time of use, it shall be sufficiently dry to flow freely and free from conglomerations. Filler Material shall conform to following gradations.

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

The coarse and fine aggregates shall meet the following applicable requirements:

- i) The percentage of wear by the Los Angeles Abrasion test (AASHTO T-96) shall not be more than forty percent (40%).
 - ii) The loss when subject to five cycles of the Sodium Sulphate Soundness test (AASHTO -T-104) shall be less than twelve (12)
 - iii) The Sand Equivalent (AASHTO T-176) determined after all processing except for addition of asphalt cement shall not be less than forty five (45).
 - iv) Fine aggregates shall have a liquid limit not more than twenty five (25) and a plasticity index of not more than four(4) as determined by AASHTO T-89 &T-90
 - v) The portion of aggregate retained on the 9.5 mm (3/8 inch) sieve shall not contain more than 15 percent by weight of flat and/or elongated particles (ratio of maximum dimensions = 2.5:1)
- c) **Asphaltic Material**
Asphalt binder to be mixed with the aggregate to produce asphalt concrete shall be asphalt cement having penetration grade 40 -50, or 60–70 or 80-100 as approved by the Engineer-in-Charge, Generally it will meet the requirements of AASHTO M-20.
- d) **Sampling and Testing Schedule of Materials**
- i) Coarse Aggregates:
 - Abrasion (AASHTO T-96); 3 per source plus 1 for 5000 cum.
 - Sodium sulphate soundness (AASHTO T-104); 3 per source plus 1 for 5000 cum.
 - Stripping (AASHTO T-182); 3 per source.
 - Fractured faces, flake & elongated particles; 3 per source plus as per visual observations.
 - Specific gravity (AASHTO T-85); 2 per source for each size.
 - ii) Fine Aggregates:
 - Sand equivalent (AASHTO T- 176); or plasticity index (AASHTO T-89 andT-90); 3 per source.
 - Specific gravity (AASHTO T-84); 2 per source.
 - iii) Asphalt:
 - Specific gravity (ASSHTO T-228); 2 per shipment.
 - Penetration (AASHTO T-49); 3 per week.

21.1.23.3 Asphalt Concrete Mixture

a) **Composition**

Unless otherwise specified, the composition of the asphaltic concrete paving mixtures for concrete mix shall conform to class shown in the following table:

Sieve Designation		Percent Passing by Weight
mm	inch	
25	1	100
19	3/4	90-100
9.5	3/8	56-80
4.75	No. 4	35-65
2.38	No. 8	23-49
0.30	No. 50	5-19
0.075	No. 200	2-8

Asphalt Content Weight Percent of total mix.	3.5 (minimum)
The asphalt concrete binder course mixture shall meet the following Marshal Test Criteria:	
Compaction, no. of blows each end of specimen	75
Stability (Minimum)	1000 kg.
Flow 0.25 mm (0.01 inch)	8-14
Percent air voids in mix.	4-8
Percent voids in mineral aggregate	According to article 5.3, MS-2, (Asphalt Institute USA) edition 1993
Loss of stability	25% (Max.)
Filler/Bitumen ratio	1-1.5 (applicable to hot climate (<40°C))

b) **Job-Mix Formula**

A Job-Mix Formula (JMF) for the asphaltic concrete to be used for the project, shall be established jointly by the Engineer-in-Charge and the Contractor. Job-Mix Formula shall combine the mineral aggregates and asphalts in such proportion conforming to specification requirements.

The JMF shall be established according to the procedure prescribed by the Engineer-in-Charge.

Each JMF shall indicate a single percentage of aggregate passing each required sieve size and a single percentage of bitumen to be added to the aggregate.

After the JMF is established samples of materials taken from the asphalt plant during operations shall conform the following ranges of tolerance.

Combined Aggregates

Sieve	Permissible variation Weight of total mix. Percent by weight
Retained No.4 and larger sieves	±6.0 %
No.8	±4.0 %
No. 30	±3.0 %
No. 200	±2.0 %
Asphalt	±0.3 %

Asphalt Content

Weight percent of total mix. ± 0.3 %

In addition to meeting the above requirements, the JMF shall also satisfy other requirements as prescribed by the Engineer-in-Charge.

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.

c) **Asphalt Additive**

Cellulose Fibers shall be used as an asphalt additive with the aim of eliminating bleeding tendencies at the rate of 0.2 to 0.25 percent by weight of the total mix. Additives shall be fed by a separate feeding system or manually into pug-mill for each batch. The weight of the additive shall be determined in accordance with the percentage specified in the job mix formula.

21.1.23.4 Construction Requirements

21.1.23.4.1 Equipments

a) **Bituminous Mixing Plant**

Plants used for the preparation of bituminous mixtures shall be either "Batching Plants" conforming to AASHTO M-156 or continuous mixing as approved by the Engineer-in-Charge and shall be of adequate capacity, coordinated and operated to produce a mixture within the limits of these specifications. Mixing plant shall meet the following general requirements.

i) Sufficient Capacity:

Mixing plants shall be of sufficient capacity and coordinated to handle adequately the proposed bituminous construction. Plants shall have minimum 3 cold bins and 3-5 decks of hot sieves.

ii) Plant Scale:

Scales shall be accurate to 0-5 percent of the maximum load that may be required. Poises shall be designed to be locked in any position to prevent unauthorized change of position. In lieu of plant and truck scales the Contractor may provide an approved automatic printer system which will print the weights of the material delivered or any other weighing device found satisfactory by the Engineer-in-Charge, provided the system is used in conjunction with an approved automatic batching and mixing control system. Such weights shall be evidenced by a weigh ticket for each load, or any other weigh system satisfactory to the Engineer-in-Charge.

iii) Scales shall be inspected and scaled as often as the Engineer-in-Charge may deem necessary to assure their continued accuracy, the Contractor will have on hand not less than 10 fifty-pound weights for testing the scales,

iv) Equipment for preparation of Bituminous Material:

Tanks for the storage of bituminous material shall be equipped to heat and hold the material at the required temperatures. The heating shall be accomplished by steam coils, electricity, or other approved means so that no flame shall be in contact with the tank. The circulating system for the bituminous material shall be designed to assure proper and continuous circulation during the operating period. Provision shall be made for measuring and sampling storage tanks.

v) Feeder for Drier:

The plant shall be provided with accurate mechanical means for uniformly feeding the aggregate into the drier so that uniform production and uniform temperature will be obtained.

vi) Drier:

The plant shall include a drier or drier which continuously agitate the aggregate during the drying process. For cold type bituminous mix, equipment for mechanical cooling of the dried aggregate the temperature prescribed for cold mixtures shall be mixer to operate at full capacity.

vii) Screens:

Plant screens, capable of screening all aggregates to the specified sizes and proportions and having normal capacities in excess of the full capacity of the mixer, shall be provided.

viii) Bins:

The plant shall include storage bins of sufficient capacity to supply the mixer when it is operating at full capacity. Bins shall be arranged to assure separate and, adequate storage of appropriate fractions of the mineral aggregates. Separate dry storage shall be provided for filler or hydrated lime when used and provided with overflow pipes of a size and at such location as to prevent backing up of material into other compartments of bins. Each compartment shall be provided with its individual outlet gates shall cut off quickly and completely. Bins shall be equipped with

adequate telltale devices to indicate the position of the aggregates in the bins at the lower quarter points.

ix) Bituminous Control Unit:

Satisfactory means, either by weighting or metering, shall be provided to obtain the proper amount of bituminous material in the mix within the tolerance specified. Means shall be provided for checking the quantity or rate of flow of flow of bituminous material into the mixer.

x) Thermometric Equipment:

An armoured thermometer of adequate range in temperature reading shall be fixed in the bituminous feed line at a suitable location near the charging valve at the mixer unit. The plant shall be equipped with either an approved dial-scale, mercury actuated thermometer, an electric pyrometer or other approved thermometric instruments so placed at the discharge chute of the drier as to register automatically or indicate the temperature of heated aggregate.

xi) The Engineer-in-charge may require replacement of any thermometer by an approved temperature recording apparatus for better regulation of the temperature of aggregates.

xii) Dust Collector:

The plant shall be well equipped with a dust collector constructed to waste or return uniformly to the hot elevator all or any part of the material collected as directed.

xiii) Truck Scales:

The bituminous mixture shall be weighed on approved scales furnished by the Contractor or on public scales at the Contractors expense. Such scales shall be inspected and sealed as often as the Engineer-in-Charge deems necessary to assure their accuracy. The accuracy shall be in accordance with paragraph(ii).

xiv) Safety Requirements Adequate and safe stairways to the mixer platform and sampling points shall be provided and guarded ladders to other plant units shall be placed at all points where accessibility to plant operations is required. Accessibility to the top of truck bodies shall be provided by a platform or other suitable device to enable the Engineer-in-Charge to obtain sampling and mixture-temperature data. Hoist or pulley or pulley system shall be provided to raise scale calibration equipment, sampling equipment and other similar equipment from the ground to the mixer platform and to return. All gears, pulleys chains, sprockets, and other dangerous moving parts shall be thoroughly guarded and protected. Ample and unobstructed space shall be provided on the mixing platform. A clear and unobstructed passage shall be maintained at all times in and around the truck loading area. This area shall be kept free from drippings from the mixing platform.

b) **Hauling Equipment**

Dump trucks used for hauling bituminous mixtures shall have tight, clean smooth metal beds which have been thinly coated with an approved material (vegetable oil or soap solution). The mixture will be delivered on the road at a temperature not less than hundred and thirty (130) degree C. Drivers of Dump trucks will ensure that while reversing the vehicles, paver in not pushed back producing a hump.

c) **Bituminous Pavers**

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

The paver shall be equipped with a receiving hopper having sufficient capacity for a uniform spreading operation. The paver shall be equipped with automatic feed controls, properly adjusted

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

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

The transverse slope controller shall be capable of maintaining the screed at the desired slope within plus or minus 0.1 percent variation. Manual operation will be permitted in the construction of irregularly shaped and minor areas.

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

Reference line will be required for both outer edges of the travelled way for each main line roadway for vertical control. Horizontal control utilizing the reference line will be permitted. The grade and slope for intermediate lanes shall be controlled automatically from reference line or by mean of ski and a slope controlled device or a dual ski arrangement. When the finish of the grade prepared for paving is superior to established tolerance and when it is considered that further improvement of the line grade cross-section and smoothness can best be achieved without the use of reference line a ski-line arrangement may be substituted subject to the approval of Engineer-in-Charge. The use of reference line shall be reinstated immediately whenever the contractor fails to maintain a superior pavement. The contractor shall furnish and install all pins, bracket, tension devices, wire and accessories for satisfactory operation of the automatic control equipment.

d) **Rollers**

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

21.1.23.4.2 Preparation of Aggregates

Before being led to the dryer, coarse and fine aggregates and filler if used for the asphaltic base courses shall be placed in separate stock piles or cold bins.

Each aggregate ingredient shall be heated and dried at temperature not to exceed hundred and sixty three (163) degrees centigrade, they shall be removed from the bins and returned to their respective stock.

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

21.1.23.4.3 Asphalt Mix

Asphalt cement shall be heated within temperature range of hundred and thirty five (135) degrees to hundred and sixty three degrees (163) centigrade at the time of mixing.

Dried aggregates weighted and drawn to pugmill shall be combined with proportionate amount of asphalt cement according to the job mix formulas. Temperature of asphalt, except for temporary fluctuation, shall not be lower than 15 degrees centigrade below the temperature of the aggregates at the time the materials enter into the pugmill.

In no case shall the temperature of asphalt mix exceed hundred and sixty three (163) degree centigrade when discharged from the pugmill.

21.1.23.4.4 Testing of Asphalt Mix

At least three test shall be performed on daily production to check;

- Extraction (Percentage of bitumen)
- Gradation
- Bulk specific gravity
- Air Voids
- Void filled with bitumen

21.1.23.4.5 Preparation of Base of Existing Pavement Surface

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

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

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

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

A thin coating of bituminous material shall be placed on contact surface of curbing, gutters, manholes, and other structures, prior to the bituminous mixture being placed against them.

21.1.23.4.6 Spreading and Finishing

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

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

The outer edges of wearing course shall be cut back to a good alignment, parallel with the road alignment. This will require a small additional width of wearing course to be laid.

The Contractor should allow, within his bid rates, for this additional width and for all cutting back wearing course, which will not be measured for payment. Tack coating of vertical faces will not be measured for payment.

On areas where irregularities or unavoidable obstacles make the use of mechanical spreading and finishing equipment impracticable, the mixture shall be dumped spread and screeded to give the required compacted thickness ensuring even distribution of course and fine material.

When production of the mixture can be maintained and when practical; pavers shall be used in parallel formation along the length of the road to place the wearing course in adjacent lanes and shoulders.

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

21.1.23.4.7 Compaction

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

Initial or breakdown rolling shall be done by means of either a tandem steel roller or three wheeled steel roller. Rolling shall begin as soon as the mixture will bear the roller without undue displacement.

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

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

Rollers shall move at a slow but uniform speed with the drive roll or wheels nearest the paver. Rolling shall be continued until all roller marks are eliminated and a minimum density of Ninety seven (97) percent of a laboratory compacted specimen made from asphaltic material is obtained for daily density.

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

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

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

Any mixture that becomes loose and broken mixed with dirt, or is in any way defective in finish or density shall be removed and replaced with the surrounding area. Mix in any area showing excess of deficiency or bituminous material shall be removed and replaced.

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

21.1.23.4.8 Frequency of Testing for Cores

Core shall be taken for each seven hundred fifty (750) square meters of base or fraction thereof in special cases. If the core so taken shall fail against the specified density, then two (2) additional cores shall be taken in the longitudinal alignment of the road at an interval of three (3) meters on either sides with respect to the failing core and shall be tested against field density. If these core pass, then the individual compaction of the core shall not be less than Ninety three (93) percent and average of these three cores, in no case be less than Ninety five (95) percent. If average of the cores further fails against compaction, then, retake the cores at a distance of fifteen (15) meters on either side and compactionshall be checked in the same fashion. In case of failure of the average of these five cores, the failed area shall be removed and subsequently be replaced by specified mix in an approved manner under the expense of Contractor.

21.1.23.4.9 Pavement Thickness and Tolerances

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

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

For determination of the average thickness, six (6) cores per Kilometer shall be taken or as directed by the Engineer-in-Charge. Unless otherwise permitted, cores extracted for thickness measurement shall not be used for density determination and density cores shall not be used for thickness measurements.

When layer thickness of asphaltic base source is deficient by more five (5) mm from that specified in the drawings, the deficiency shall be removed with satisfactory base course material and or made up by additional asphalt concrete wearing coarse thickness without extra cost to the Employer. If such remedial action is authorized, revised thickness determinations shall be made by measurements of new cores taken after placing of "Asphaltic Wearing Course" material or as directed by the Engineer-in-Charge. If base course deficiencies are corrected in this manner, full payment for the "Asphaltic Base Course" will be made to the Contractor but no additional payment will be made for the increase in thickness of the "Asphaltic Wearing Course".

21.1.23.5 Weather Limitations

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

21.1.24 ASPHALT CONCRETE WEARING COURSE – PLANT MIX

21.1.24.1 General

The work shall consist of furnishing aggregates and asphalt binder plant, labour, equipment mixing transporting, spreading compacting the mixture in an approved manner on a primed or tacked, base, sub-base, sub-grade 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-in-Charge.

21.1.24.2 Material Requirements

The materials consisting of Mineral Aggregates, Asphalt Materials shall conform with provisions of Sub-section 21.1.23.2.

21.1.24.3 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.

Asphalt Concrete Wearing Course Requirements		
Mix Designation	Class-A	Class-B
Compacted thickness	50-100 mm	35-60 mm
US Standard Sieve size Percent Passing by weight		
1" (25 mm)	100	-
¾" (19 mm)	90-100	100
½" (12.5 mm)	-	75-90
3/8" (9.5 mm)	56-70	60-80
No.4 (4.75 mm)	35-50	40-60
No.8 (2.38 mm)	23-35	20-40
No. 50 (0.300 mm)	5-12	5-15
No. 200 (0.075 mm)	2-8	3-8
*Asphalt Content weight Percent of total mix	3.5 (Min)	3.5 (Min)

* The exact percentage of asphalt content shall be determined through JMF.
The asphalt concrete wearing course mixture shall meet the following Marshall Test Criteria:

Description	Standard
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	5 - 8
Percent voids filled with bitumen	65 - 75
Loss of Stability	20% (Max)

21.1.24.4 Job-Mix Formula

The Job-Mix Formula (JMF) shall comply with the provisions of Sub-section 21.1.23.3(b).

21.1.24.5 Asphalt Additives

The same as for Sub-section 21.1.23.2(c).

21.1.24.6 Construction Requirements

Construction requirements for this job shall conform to the requirements as specified for Asphaltic Concrete Base Course Plant Mix under Sub-section 21.1.20.4.

a) **Preparation of Base Surface**

Before wearing coat, the surface of the previously and accepted base course on which the mix is to be placed shall be applied a tack coat, if directed by the Engineer-in-Charge.

b) **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-in-Charge.

The tolerance in compacted thickness of the wearing course shall be \pm five percent (5%) from the desired thickness shown on the drawings. For determination of the average thickness, six cores per kilometre shall be taken. If the average thickness so determined is deficient by more than \pm 5%, the Engineer-in-Charge shall decide whether to accept the deficit thickness or to direct reconstruction.

The surface of the wearing course shall be tested by the Engineer-in-Charge using a 3 meter 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 millimetres. The cross fall (camber shall be within \pm 0.2% of that specified, and the level at any point shall be within \pm 5.0 millimetres 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-in-Charge.

21.1.24.7 Sand Flushing

Where specified, sand flushing with a mix of sand and bitumen of the specified proportions shall be applied on top of asphalt concrete road. The material requirements the preparation of the mix and application on road surface shall comply with the provisions of wearing course application.

21.1.25 SHOULDER TREATMENT

21.1.25.1 General

- a) The work shall consist of constructing shoulders of the types specified hereinafter in accordance with the specifications and in conformity to the lines, grades thickness and typical cross-section shown on the plans or established by the Engineer-in-Charge.
- b) The shoulders consist of that portion of the completed road construction which lies above the elevation of the subgrade or sub-base and which extends from the edge of the wearing course to the point of inter-section with the embankment slopes on either side of the road centreline.

21.1.25.2 Material Requirements

a) **Earth Shoulders**

The material used for "Earth Shoulders" shall consist of suitable materials from roadway or structural excavation supplemented by additional suitable material from borrow excavation or as designated on the plans and shall be obtained from sources approved by the Engineer-in-Charge.

- b) **Aggregate Shoulders**
Material used for "Aggregate Shoulders" shall be of class designated on the plans and shall conform to all the requirements of 21.1.10 "Granular Sub-base" 21.1.11, "Aggregate Base Course" or 21.1.12, "Water Bound Macadam Base".
- c) **Asphaltic Materials**
Materials for surface treatment of shoulders shall be liquid asphalts, emulsified asphalts or asphalt cement as specified or shown on the drawings and in the Bill of Quantities. Asphaltic materials shall conform to all the requirements of 21.1.18 for the type specified.

21.1.25.3 Construction Requirements

- a) **General**
All shoulders shall be formed and compacted as soon as practicable after the asphalt paving on the traffic lanes is completed, however in the case of cement concrete surfacing, shouldering operation shall not be initiated prior to Engineer-in-Charge's approval.
- b) **Shouldering and delineation**
On Projects that carry traffic through construction, the contractor shall begin shouldering on the second day of the laying of the final roadway surfacing layer, unless weather conditions prevent this operation, in which case the shouldering shall begin as soon as the weather does permit. If the contractor fails to begin the shouldering within a reasonable time after the last layer has been laid, whether the project has a flow of traffic through construction or not, the Engineer-in-Charge may order the contractor to cease paving until the shoulder work has begun. The shouldering shall be a continuous operation from that time on until completion, with the weather being the only delaying factor. The Contractor shall, on roads under traffic or as directed by the Engineer-in-Charge, delineate the edge or pavement as soon as the surfacing is begun and maintain the delineation until the shoulders are completed. The delineators shall be approved prior to use and shall be placed at the edge of the surfacing at approximately one hundred (100) meter intervals. The cost of this delineation will be considered subsidiary to other items in the Bill of Quantities and will not be paid for directly.
- c) **Earth Shoulders**
Earth Shoulders shall be constructed in accordance with the applicable paragraphs under item 21.1.8.
- d) **Aggregate Shoulders**
Aggregate shoulders shall be constructed in accordance with the requirements of item 21.1.10, 21.1.11 or 21.1.12.
- e) **Asphaltic Treatment of Shoulders**
The asphaltic treatment of the prepared shoulders shall be either a bituminous surface treatment or seal coat or a layer of asphaltic concrete as shown on the plans or in the Bill of Quantities. Detailed construction procedures for the particular treatment specified are outlined under Sub-Sections 21.1.19, 21.1.23 and 21.1.24.

21.1.26 BIT – MAC

21.1.26.1 General

This work shall consist of furnishing and mixing aggregates with asphalt binder at site in mobile mixing plant, spreading, compacting on an approved primed subgrade, sub base or base course, for potholes, repair, levelling course and wearing course in accordance with the specification and in conformity with the lines, grade, thickness and typical cross-section shown on the Drawings or as directed by the Engineer-in-Charge including sealing of cold bituminous surface cracks with sand-bitumen slurry.

21.1.26.2 Material Requirements

A. Mineral Aggregate

Mineral aggregates for BIT-MAC Construction shall consist of coarse aggregates, fine aggregate and filler material, all conforming to the following specification requirements:-

- a. Coarse aggregate which is the material retained on No.4 Sieve and Passing 25.4mm sieve, shall consist of crushed rock, crushed boulder, or crushed gravel. It shall be clean, hard, tough, sound, durable, free from decomposed stones, organic matter, shale, clay lumps or other deleterious substances. Rock or boulders, from which coarse aggregates shall be obtained, must be of uniform quality throughout the quarry location.
- b. Fine aggregates which is the material passing No. 4 sieve shall consist of crushed sand.
- c. When combined gradation of coarse and fine aggregates is deficient in material passing No. 200 sieve, mineral tiller shall be added. The filler material shall consist of finely divided rock dust from sound rock, hydrated lime or hydraulic cement. At the time of use it shall be sufficiently dry to flow freely, free from lumps.
- d. Aggregate should be stored on hard clean surface so as to facilitate prompt inspection and control, Private property shall not be used for storage purposes without written consent of the owner or lessee and payment to him by contractor, if necessary. Material shall be stored in such a way as to prevent segregation and coning to ensure proper control of gradation. The equipment and methods used for stockpiling and removing aggregates shall be such that no degradation of aggregate will result and no appreciable amount of foreign material will be incorporated into the aggregate. When aggregates containing a wide range of sizes are to be incorporated, they must be stockpiled separately to prevent intermingling. Mineral Filler must be protection from moisture to eliminate caking and hardening.

B. Bituminous Binder

Asphaltic binder used shall conform to standard specification of petroleum asphalt having grades 60-70 or 80-100 penetration. Generally, it will meet the requirement of AASHTO M-20.

C. Design Characteristics

Optimum Grading curves for different types of hot mix asphaltic design related to quantum of repair work and maximum size of aggregates, given in Table 21.1.26(a), must be carefully selected considering average thickness of patches.

Design sheet under Table 21.1.26(a) showing Dense Graded Mix used for levelling courses and potholes should use little asphalt content of such quantity to prevent bleeding through subsequent wearing course or surface treatment. Design sheet under Table No. 21.1.26(b) is suitable for open graded wearing course having rough surface texture with good skid resistance thus having minimum bleeding tendency.

21.1.26.3 Construction Requirements

a) Mixing Requirement

Asphalt cement shall be heated to a max. temperature of 163 degrees centigrade at the time of mixing. Asphalt cement heated above 163 degrees centigrade shall be rejected. Temperature of asphalt shall be checked frequently. Each aggregate ingredient shall be heated to temperature 150-160 degrees centigrade for at least six(6) minutes before mixing of asphalt cement to ensure complete drying of aggregates. The range of heating of aggregates shall be strictly followed to ensure proper coating of aggregates. Fine aggregates shall be introduced into the dryer (mixer) first followed by the coarse aggregates to assure proper mixing. Quantity of aggregates fed to dryer (mixer) must be accurately controlled by suitable measuring device (Iron box) having predetermined volume of one(1) cubic foot or as instructed by Engineer-in-Charge.

Both bitumen and aggregates must be heated before they are combined in the mixer drum. Mixing temperature should be kept within the range of 140-170 degrees centigrade.

To achieve uniform mixing and proper coating, aggregates and asphalt cement must be thoroughly mixed for a minimum duration of ninety(90) seconds. Mixing time shall be prolonged to hundred (100) seconds if coating of aggregates is not proper. After one hundred and twenty (120) seconds if it is still not possible to get good coating, the aggregate drying time must be increased.

b) Deep Patches/Pot Holes

The surfaces of base course thus prepared as mentioned under Sub-Section 21.1.11 shall be primed to receive Bit Mac in a thickness as per drawings or as directed by the Engineer-in-Charge, Bit Mac shall be spread carefully to avoid segregation. Compaction shall be done with equipment suited to the size of job. A vibratory plate compactor is recommended for small patches. Whereas roller may be more practical for larger areas, Straight edge or string line shall be used to check riding quality and the alignment of the patch.

c) Levelling Course

All local depressions corrugated surface, ripples across the pavement should be rectified before levelling course is placed. Clean the area free of dust or other loose material with mechanical broom or compressed air. Apply light tack coat, 0.2 to 0.7 litres per square meter of A.C 80/100 Penetration grade. After drying dense graded hot Bit-Mac shall be spread in layer not more than seven(7) centimetres in thickness. Spread shall be done carefully to prevent segregation and compact with steel wheeled and pneumatic tyred roller. For small pot holes hand tempers shall be allowed. Use string line to check the riding quality of the levelling course.

21.1.26.4 Wearing Surface

a) Mini Mixing Plant

Local made bitumen aggregate mixer equipment used for preparation of Bit Mac shall be in good working condition of sufficient capacity, capable of being operated to produce a uniform blend with the given ingredients

Table 21.1.26 (a)

DESIGN SHEETS FOR DENSE GRADED HOT MIX. FOR LEVELING AND POTHOLES, RELATED TO THICKNESS WITH ASPHALT BINDER 60-70 OR 80-100 PENETRATION GRADE.										
AGGREGATE IN MIX		FILLER	FINE AGG.	COARSE AGGREGATES				BITUMEN USED.	REMARKS	
Sieve Size	Inch (mm)	200 (0.075)	No. 8 (2.36)	No. 4 (4.75)	3/8" (9.5)	1/2" (12.5)	3/4" (19)	1" (25)	4% by Wt. of Mix.	Minimum Layer Thickness:-20 mm Aggr. max size : 9 mm Rate of Aggr. Appl. :-50 Kg/SM
Specification Range		4-12	43-56	55-75	90-100					
Allowed % Passing		9	48	65	100					
% by Weight		57%		43%						
Qty. by Proportion.		4		3						
Specification Range		3-11	30-45	46-60	72-87	87-100			4% by Wt. of Mix.	Minimum Layer Thickness: 30mm Aggregate Size:- 12mm Rate of Aggr. Appl.:- 70Kg/SM.
Allowed % Passing		8	36	54	80	100				
% by Weight		46%		54%						
Qty. by Proportion.		3		4						
Specification Range		4-11	32-46	46-60	65-80	75-88	90-100		3.5% by Wt. of Mix.	Minimum Layer Thickness:- 50mm Aggr.size:- 20mm Down Rate of Aggr. Appl.: 115 Kg/SM.
Allowed % Passing		8	38	53	73	82	100			
% by Weight		46%		54%						
Qty. by Proportion.		3		4						
Specification Range		4-12	24-37	34-47	49-61	57-70	70-87	88-100	3.5% by Wt. of Mix.	Minimum Layer Thickness:-50mm Aggr. size:- 20mm Down Rate of Aggr. Appl.: 150 Kg/SM.
Allowed % Passing		8	30	40	54	62	76	100		
% by Weight		46%		54%						
Qty. by Proportion.		3		4						

b) Preparation of Aggregates

Aggregates shall be stored and handled as discussed under 21.1.24.2, Material Requirement.

c) Hauling Equipment

Bit-Mac mixed material shall be delivered in tight, clean and smooth metal bed hand trolleys, or any method as convenient to the Contractor and approved by the Engineer-in-Charge.

d) Preparation of Base or Existing Pavement Surface

Surface of base or existing pavement upon which Bit-Mac mix is to be placed shall be cleaned by means of compressed air to remove dust or as approved by the Engineer-in-Charge.

Priming shall be done in a manner as described in Sub-Section 21.1.20. The rate of application of prime coat shall be 0.8 – 1.5 litres per square meter. Tack coat shall be done in a manner as described in 21.1.22. The rate of application of tack coat shall be 0.2 – 0.4 litres per square meter. When surface of existing pavement or old base is irregular, it shall be brought to uniform grade and cross-section by levelling course as described above. Sand bitumen slurry to seal the cracks in clod bituminous surface shall be injected by pressure pumps with nozzles filled at the end instead of spray pipe in conventional Harris trolley.

e) Spreading and Finishing

Bit-Mac mixture shall be placed on approved surface, struck off to required section manually with rakes or hand tools by experienced foreman, distributed over the entire width or partial width as required. All mixtures shall be spread at temperatures not less than one hundred and forty (140) degrees centigrade. Mixture shall not be placed on any wet surface or when the atmospheric temperature is below five (5) degree centigrade or when the weather is foggy or rainy.

f) Compaction

Roller shall be steel wheel or pneumatic tyred. The roller(s) shall be in good working condition, capable of reversing without backlash, capable to be operated at speeds slow enough to avoid displacement of Bit Mac. The number and weight of rollers shall be sufficient to compact the mixture while it is still in workable condition to obtain compaction to Engineer-in-Charge satisfaction. The use of equipment which results in excessive crushing of aggregates shall not be permitted.

After spreading and strike off as soon as the mix condition permit the rolling to be performed without excessive shoving or tearing, the Bit Mac mixture shall be thoroughly and uniformly compacted. Rolling will not be prolonged to avoid appearance of cracks. Rolling will be done longitudinally, beginning at the lower side of the spread and proceeding towards the higher side, overlapping successive trips by at least one half (1/2) the width of rear wheels of roller.

Roller shall be operated at speed slow enough to avoid displacement of mixture. To prevent adhesion of mixture to rollers, the wheels of rollers shall be kept properly moist with water, but avoiding excess water. Rolling shall be continued until all roller marks have been eliminated.

Along forms, curbs, headers, walls and other places not accessible to the roller, the mixture shall be thoroughly compacted with hot hand tampers or mechanical tampers. Any mixture that has become cold enough, mixed with dirt or is defective in any way shall be replaced with fresh hot mixture and compacted to conform the requirement.

21.1.27 PORTLAND CEMENT CONCRETE PAVEMENT

21.1.27.1 General

The work specified in this section consists of the construction of Portland Cement Concrete pavement constructed in one course on a prepared sub-grade or base in accordance with these specifications and in conformity with the lines and cross-sections shown on the plan and shall include curves where specified. The concrete shall be composed of mixture of Portland Cement,

fine aggregate, coarse aggregate and water with air-entertaining admixture where specified, conforming in general to the requirements contained in Section 5 – Plain & Reinforced Concrete.

When reinforced cement concrete is called for in the contract document, the concrete shall be reinforced with steel bar or steel mesh in accordance with the details shown on drawings.

21.1.27.2 Materials

a) **Portland Cement**

The Portland cement shall conform to the requirement, for Portland cement contained in Section 5, Plain & Reinforced Concrete.

b) **Fine Aggregate**

Fine aggregate shall be natural sand or other approved inert material with similar characteristics, of clean, hard, strong durable, uncoated particles, free from lumps of clay, soft or flaky particles, loam, frost or organic matter, unless otherwise approved, the grading shall meet the following requirements ;

Sieve Size	Percentage Passing by Weight
3/8 inch	100
No. 4	95 –100
No. 16	45 – 80
No. 60	10 – 30
No. 100	2 – 10
No. 200	0 – 4

c) **Coarse Aggregate**

The coarse aggregate used shall consist of crushed stone gravel or other approved inert material of similar characteristics having hard, strong, durable, uncoated pieces free from deleterious substances.

Unless otherwise approved coarse aggregate shall be separated into two grading classifications and each classification shall be stored separately in such a manner as will prevent segregation or combining of the two classifications previous to proportioning. Grading of the two classifications shall be as follows:

Sieve Size	Percentage Passing by Weight
Number 1	
1 ½ inch	100
1 inch	95 –100
½ inch	25 – 60
No. 4	0 – 10
No. 8	0 – 5
Number 2	
2 ½ inch	100
2 inch	95 –100
1½ inch	35 – 70
1 inch	0 – 15
½ inch	6 – 5

These two classifications shall be proportioned by weight at the time of batching or mixing in the proper proportions by volume, to meet the following grading requirements when tested in accordance with AASHTO T-27.

Sieve Size	Percentage Passing by Weight
2 ½ inch	100
2 inch	95 – 100
1 inch	35 – 70
1½ inch	10 – 30
No. 4	0 – 5

The percent of wear of coarse aggregate at 500 revolutions, when tested in accordance with AASHTO T-96 shall not exceed 40.

d) **Water**

Water for concrete shall conform to the requirements contained for “water” as per Section 5 – Plain & Reinforced Concrete.

e) **Air-entraining Admixture**

The admixtures when designated to be used in the concrete shall conform to the requirement of AASHTO M-154.

f) **Expansion Joint Fillers**

i) **Soft Wood-board Expansion Joint Filler:**

a) General Requirements:

The boards shall be of sound heart wood. Occasional small sound knots and medium surface cheeks will be permitted provided the board is free from any defects that will impair its usefulness for the purpose intended. The joint filler may be composed of more-than one length of board in the length of the joint, but no board of a length less than 6 feet long be used and the separate pieces shall be held securely to form a straight joint.

Board joint-materials shall be immersed in water for a period of not less than 24 hours before being installed in the pavement slab. The boards shall not be allowed to dry out, and shall be kept thoroughly wet until installed in the slab.

b) Weight per cubic foot:

The oven dry weight of the soft wood shall not exceed 25 pounds per cubic foot.

c) Dimension shall be as specified or shown on the drawings and tolerance of +1/16 inch thickness, + 1/8 inch depth and +1/4 inch length shall be permitted.

d) Compression:

The load required to compress the material in an oven-dry condition to 50 percent of its thickness for test shall not be more than 1,500 pounds per square inch.

e) Method of Testing:

The sampling and testing shall be in accordance with the standard method of AASHTO T-52.

ii) **Mixed Asphalt and Mineral Filler:**

a) General Requirements:

The mixtures of asphalt and, mineral filler are also used for filling joint in the pavement. The filler shall be prepared by mixing approved asphalt with cement and sand as specified. It shall be uniform in appearance and consistency and shall not foam when heated to a temperature of

- 350°F.
- b) Asphalt:
The asphalt used, in the preparation of the asphalt mineral filler mixture shall conform to the requirements of standard specifications for asphalt cement (prepared from petroleum) as specified under Clause 21.1.20.2(c).
- c) Cement and Sand:
The cement and sand shall be as specified under Clause 21.1.20.2(a) & (b) respectively.
- iii) **Joint Sealer (Hot-poured Elastic Type):**
- a) General Requirements:
The joint sealer shall be as approved and a rubber asphalt compound resilient and adhesive in nature capable of effectively sealing joints in concrete against the infiltration of moisture and foreign material during the expansion and contraction cycles due to temperature changes. It shall not flow from the joint or be picked up by a vehicle tyres at summer temperatures
Pour point shall be at least 20°F lower than the safe-heating temperature.
Penetration at 77°F, 100 grams 5 seconds shall not exceed 90.
- b) Bond:
The sealer shall be tested at 0°F for five complete cycles. The development at any time during the testing procedure, of a crack, separation or other opening at any point is over 1/4 inch deep, in the sealer or between the sealer and mortar block, shall constitute failure of the test specimen. The depth of the crack, separation or opening shall be measured perpendicular to the side of the sealer showing the defect.
- c) Method of sampling and Testing:
The sampling of the material and the testing of physical requirements specified above shall be done in accordance with the AASHTO designated T-40 and T-187 respectively.
- d) PVC Water Stop:
The PVC water stop shall comply with applicable provisions of Section 5 – Plain & Reinforced Concrete.
- e) Polythene Sheeting:
Polythene sheeting for placing immediately below concrete slabs shall be 0.065 mm thick or having a minimum weight of fifty(50) grams per square meter (whichever is greater) made from polythene or other approved hydrocarbon thermoplastic resin (produced by the polymerization of ethylene under high pressure and density) and given an anti-static treatment to reduce dust attraction and reduce friction. The sheeting shall have the minimum mechanical properties shown in table as follows:

PROPERTIES OF POLYTHENE SHEETING

Properties	Machine Direction	Transverse Direction
Tensile Strength Method ASTM D882-73 kgf/Sq. M	140	105
Elongation at Break %	150	500
Tear Strength Elmendorf Method	390	310
ASTM D 689-62 (1974) kg/cm ²		

- f) Dowel Tie, Reinforcement Bars:
The bars shall be deformed bars of the size shown on the plans and shall conform to the requirements of steel Section 5 – Plain & Reinforced Concrete.
- g) Bituminized Water Proof Paper:
The bituminized water proof paper shall comply with the provisions of clause 8.2.3.2 as approved by the Engineer-in-Charge.

21.1.27.3 Construction Details

a) Pavement Base:

The base upon which the concrete pavement is laid shall have been constructed or prepared as specified on drawings and directed by the Engineer-in-Charge.

The base shall be smooth compacted and true to the grades and cross-sections including the cushion of sand, polythene sheet, bituminized paper shown on the plans and shall be so maintained, as provided throughout the period of placing concrete pavement. The base under polythene sheet & bituminized paper shall be moistened immediately prior to placing concrete.

To ensure the proper depth and section, a template to depth and section and resting on accurately set aside forms shall be moved over the surface immediately before placing concrete; and any irregularities shall be immediately corrected. High spots shall be planed down; and the Contractor shall have the option of either filling low spots to the proper elevation with approved material, which shall be watered, compacted and struck off to therequired grade or of placing additional concrete. No measurement or payment will be made for such additional concrete.

For reinforced pavement, the reinforcing bars shall be placed as shown and on drawings complying with the provisions of Section 5 – Plain & Reinforced Concrete.

b) Forms

Forms shall be made of steel, of an approved section; with a base width of at least 8 inches and the depth shall be equal to the thickness of the pavement at-the edge. The forms shall be staked with stakes, and stakes shall be of length satisfactory to the Engineer-in-charge. Batch section of forms shall have a stake pocket at each end and at intervals of not more than 5 feet in between. The stake pockets shall have a device for locking the form to the steel stakes. Each section of forms shall be straight and free from bends and warps at all times. No section shall show a variation greater than 1/8 inch in 10 feet from a true plane surface on the top of the form; and the inside face shall not vary more than 1/4 inch from a plane surface.

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

Forms shall be set to the required lines and grades well ahead of placing concrete; preferably not less than 600 feet. Forms shall not be removed for at least 12 hours after the concrete has been placed. Forms shall be carefully removed in a manner as to avoid damage to the pavement. Under no circumstances will the use of pry bars between the forms and the pavement be permitted.

Forms shall be thoroughly cleaned and oiled each time they are used.

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

c) Proportioning

Proportioning & mixing of concrete shall be by volume as specified and shall be carried out in accordance with the applicable provisions of Section 5 – Plain & Reinforced Concrete. The fresh concrete shall be tested according to the provisions of the same Section.

No change in the source, character or grading of the materials shall be made without prior permission of the Engineer-in-charge.

d) Moisture content of Aggregate

The moisture content of the aggregate shall be such that no visible separation of moisture and aggregate will take place during transportation from the proportioning plant or site to the point of mixing. Aggregate containing excess moisture shall be stockpiled prior to use until sufficiently dry to meet the above requirement.

e) Handling of Materials

Materials shall at all-time be handled in such a manner as will preserve their integrity and prevent loss. The equipment and methods used for stockpiling aggregates and for moving the aggregates from the stockpiles to the mixer shall be such in the opinion of the Engineer-in-charge that no degradation or segregation of the aggregate will result and that no foreign material will be incorporated into the aggregate.

Aggregates shall be transported from the proportioning plant in batch boxes, vehicle bodies or other containers of sufficient capacity and adequate construction to carry properly the entire volume required per batch and shall be delivered to the mixer with each batch separate and intact without loss.

Loose cement shall be transported to the mixer either in waterproof compartments carrying the full amount of cement required for the batch. Where cement is placed in contact with damp aggregates the materials may be rejected unless mixed within one hour of such contact. Cement in original factory packages may be transported on top of the aggregates.

f) Consistency

The slump of the pavement concrete shall be from one to three inches, as determined by the Engineer-in-charge. The slump shall not vary more than one inch from batch to batch.

g) Placing Concrete

Concrete shall be placed on the prepared sub-grade moistened as directed prior to the placement of polythene sheet, bituminized paper as specified. The concrete shall be placed in such a manner as will require as little re-handling as possible and avoid segregation of materials.

If required by the Engineer-in-charge the forms shall be wetted immediately prior to the placing of concrete. All operations shall be in accordance with provisions of Section 5 – Plain & Reinforced Concrete.

i) Cold Weather Concreting

Except by specific written authorization from the Engineer-in-charge concreting operations shall not be continued when a descending air temperature in the shade and away from artificial heat falls below 40°F, nor shall operations be resumed until as ascending air temperature in the shade and away from artificial heat reaches 35°F. Mixing and placing concrete in any day, shall continue not later than the period which allows sufficient time remaining to finish and protect the concrete already poured, before the air temperature drops to 35°F. Concrete shall not be placed on frozen ground.

When concreting is authorized during cold weather the aggregates may be heated by the use of steam coils or dry heat before being placed in the mixer. The aggregates shall be heated uniformly, but not hotter than 150°F. The apparatus used shall preclude the possible occurrence of overheated areas which might injure the materials. Water may be heated, but shall not be hotter than 150°F. Unless otherwise authorized the temperature of the mixed concrete shall be not less than 60°F nor more than 90°F when it is placed. After placement of concrete, blanketing material shall be provided and shall be spread over the pavement to a sufficient depth to prevent freezing of the concrete.

The Contractor shall be responsible for the protection of the concrete placed during cold weather, and any concrete injured by frost action shall be removed and replaced without expense to the department.

j) Joint

i) General Requirements:

All joints shall be constructed due to alignment and grade in accordance with the details shown on the drawings and as specified herein. In regard to tie bars and joint assemblies, such stakes, brackets, or other devices shall be used as necessary to keep the entire joint assembly in true vertical and horizontal position.

ii) Construction Joints

At the end of each days concreting or where an interruption in the work of more than 30 minutes occurs, a construction joint shall be placed as shown on the plans or as desired by the Engineer-In-charge. Construction joints shall be placed only at the location of a contraction joint or at the mid-point of the slab between two adjacent, normally spaced transverse joints. Any excess concrete shall be disposed of as directed by the Engineer-in-charge. The spacing of subsequent transverse joints shall be measured from the transverse contraction joints last placed. All transverse joints, except mid-point construction joints shall be continuous across the full width of the pavement.

iii) Longitudinal joints

Longitudinal joints shall be constructed in accordance with the details shown on the drawings. Where specified, steel tie bars of the dimensions shown and meeting the requirements as specified herein shall be placed across the longitudinal joint as shown on the plans. The tie bars shall be held in position, at the spacing shown perpendicular to the joint and at the correct distance from the surface of the slab, by metal chains, pins, or other supports. Instead of using supports, the tie bars may be floated in place by approved methods.

When the lanes are poured separately, the tie bars may be set temporarily along the form and then straightened into the correct position before the next lane of pavement is poured.

Where sawed longitudinal joints are required or permitted, the joint shall be sawed after the concrete has hardened, but before traffic of any kind is permitted on the pavement. The joint shall conform to the requirements specified herein under sawed joints.

Where curb and gutter is to be constructed adjacent to new concrete pavement, the curb and gutter shall be placed after the pavement, and the joints in the curb shall be opposite each transverse joint in the adjoining pavement.

iv) Transverse Contraction Joints

1. General Requirements:

Transverse contraction joints shall consist of formed control joints and sawed joints conforming to the requirements of the roadway standards and these specifications.

Unless otherwise specified on the plan or in the special provisions and except as otherwise provided herein, the first lane poured shall have formed control joints spaced at a maximum of 60 feet and the intermediate joints at 15 feet centre shall be sawed joints. Under certain conditions, if deemed advisable by the Engineer-in-charge he may order that formed control joint be used instead of sawed joints. In lanes adjacent to previously constructed lanes, all contraction joints shall be opposite to joints or cracks which have opened in the previously constructed slab and these joint shall be formed control joints.

2. Formed Control Joints:

The formed control joints shall be constructed by making a transverse groove in the pavement lane and installing therein steel strips as joint inserts spaced as shown on the roadway standards or on the plans. The joint inserts shall be maintained true to line and grade at an elevation not more than

1/4 inch below the pavement surface. The joint inserts shall consist of steel strips 2¼ inches wide and maximum of No. 12 gauge. Each strip shall be furnished in one piece. Splicing, except by welding, will not be permitted: Any strips damaged in installing or during the finishing of the pavement shall be replaced with undamaged strip.

The joints inserts shall be set following the first pass of the finishing equipment, and may be installed either by a machine or by hand methods as approved by the Engineer-in-charge. If hand methods are used, a groove shall be formed by means of a "T" iron cutter with a blade at least 1/4 inch greater in depth than the joint strip. The joint inserts shall then be placed in the groove by means of a metal installing device with a backup plate extending full depth of the strip on one side and 3/4 inch on the other side and it shall have a gauge resting on each side of form to control the depth to which the strip is set. Mortar shall be floated into the groove around the joint after the installing device is removed and before any finishing equipment passes over the joint.

When it is necessary, to place joint inserts temporarily at a distance greater than 1/4 inch below the pavement surface in order to prevent damage to the inserts by finishing equipment, the inserts shall be raised to the required elevation immediately after the last pass of the mechanical float.

3. **Sawed Joints:**

Sawed joints shall be formed by cutting a groove in the pavement with multiple blade power concrete saw. The grooves for construction joints shall be cut 2 inches deep and the width shall not exceed 3/16 inch.

If possible all joints shall be sawed before uncontrolled shrinkage cracking takes place, usually four to twenty-four hours after placing, but sawing shall not be done until the concrete has hardened to the extent that tearing and ravelling is not excessive. The exact time for all sawing shall be determined by the Engineer-in-charge. In case it is found impossible to saw all joints before uncontrolled cracking takes place, the transverse contraction joints 30 feet or more apart shall be sawed before uncontrolled cracking takes place and the intermediate joints sawed immediately thereafter.

Any procedure for sawing joints that result in premature and uncontrolled cracking shall be revised immediately by adjusting the sequence of sawing the joints, by adjusting the time interval involved between the placing of concrete and the sawing of the joints, or by placing formed control joints.

In addition to the multiple blade power saw, the Contractor shall keep a stand-by concrete saw on the project at all times while concrete operations are in progress. This saw may be a single blade saw.

4. **Transverse expansion joints:**

Transverse, expansion joints shall be constructed at the end of bridges and culverts at grade and at all obstructions that extend into or through the pavement, as shown on the roadway standards or on the plans and as specified herein.

Transverse expansion joints shall be formed by a preformed or redwood joint filler conforming to the requirements specified herein under "Expansion Joint Filler" and as shown on the roadway standards or on the plans. The joint filler shall be held in position by positive means.

k) **Spreading, Finishing and Floating**

a) **General Requirement**

Except as otherwise specified, the striking off, compacting and floating of concrete shall be done by mechanical methods. Where the Engineer-in-charge determines that it is impracticable to use mechanical methods, manual methods of spreading, finishing and floating may be used on pavement lanes, of widths less than 10 feet.

b) **Mechanical Methods**

1. Spreading and Finishing:

The concrete shall be spread uniformly between the forms, immediately after it is placed, by means of an approved spreading machine. The spreader shall be followed by an approved finishing machine equipped with two oscillating or reciprocating screeds. The spreading machine or the finishing machine shall be equipped with vibrating equipment that will vibrate the concrete for the full paving width. Internal vibrators shall be used adjacent to the longitudinal edge of the pavement. These vibrators shall be attached to the rear of the spreading machine or to the finishing machine. Vibrators shall not rest on new pavements or side forms or contact any tie bars, and power to the vibrators shall be such that when the motion of the machine is stopped, vibration will cease. The rate of vibration shall be not less than 3,500 vibrations per minute.

The concrete shall be spread full width before being struck off by the finishing machine. The concrete shall be struck off and compacted so that the surface will conform to the finished grade and cross-section shown on the plans and at the same time leave sufficient material for the floating operation. The spreading finishing machine shall move over the pavement as many times and at such intervals as may be required by the Engineer-in-charge to ensure thorough compaction.

2. Floating:

Except as otherwise specified, after the pavement has been struck off and compacted, it shall be finished with an approved longitudinal float.

The Contractor may use a longitudinal float composed of one or more cutting and smoothing floats, suspended from and guided by a rigid frame. The frame shall be carried by four or more visible wheels riding on and constantly in contact with the forms.

The Contractor may use a longitudinal float which works with a sawing motion, while held in a floating position parallel to the road centre-line and passing gradually from one side of the pavement to the other. Movements ahead along the centre-line of the road shall be in successive advances of not more than 1/2 the length of the float.

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

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

c) **Manual Methods**

1. Striking-off and compaction:

When striking-off and compacting by manual methods are permitted, the concrete shall be approximately levelled and then struck-off to such an elevation that when properly compacted, the surface will conform to the required grade and cross-section. The strike board shall be moved forward with a combined longitudinal and transverse motion, the manipulation being such that neither end is raised from the side forms during the process. While striking-off, a slight excess of concrete shall be kept in front of the cutting edge at all times.

Prior to tamping, the concrete along the forms shall be thoroughly spaded or vibrated. The entire area of pavement shall be tamped or vibrated in a manner that will ensure maximum compaction. The concrete shall be brought to the required grade and shape by the use of a tamper consisting of a heavy plank whose length exceeds the width of the pavement by one foot, or by the use of a mechanical vibrating unit spanning the full width of the spread. The tamper shall be constructed

with proper trussed rods to stiffen it and prevent sag and shall be shod with a heavy strip of metal for finish as required. The tamper shall be moved with a combined tamping and longitudinal motion, raising it from side form and dropping it so that the concrete will be thoroughly compacted and rammed into place. A small surplus of concrete shall be kept in front of the tamper or vibrating unit and tamping or vibrating shall continue until the true cross-section is obtained and the mortar flushes slightly to the surface.

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

Where hand tamping is permitted, not less than two strike boards or tampers shall be used for production in excess of 350 cubic feet per hour. After the concrete has been compacted, it shall be smoothed with a wooden float where necessary in the opinion of the Engineer-in-charge.

2. Longitudinal Floating:

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

3. First Straight Edge Testing:

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

4. Burlap (Coarse Canvas) Dragging:

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

5. Second Straight Edge Testing:

After the concrete has hardened sufficiently to permit walking on it, the surface of the pavement shall again be tested with a 10-foot straight edge. Any portion of the pavement which shows a variation from the testing edge of more than 1/8 inch shall be corrected by cutting, or shall be removed and replaced at the expense of the Contractor.

21.1.27.4 Opening Pavement to Traffic

Pavement shall remain closed to traffic until tests show the concrete to have a minimum modulus of rupture, when tested in accordance with ASTM C-293, of not less than 600 pounds per square inch; but in no case shall the pavement be opened to traffic in less than 14 days after concrete is placed.

21.1.28 BOUNDARY PILLARS

21.1.28.1 General

The boundary pillars shall be of either precast RCC or hard stone of sound and durable quality. These shall be in blocks of size 6 inches x 6 inches x 30 inches (15x15x75 cm) unless directed otherwise by the Engineer-in-Charge. A tolerance of 12.5 mm shall be permitted in the specified

size. In the case of boundary stones of hard stone, the upper 30 cm shall be chisel dressed on all the four sides and on the top.

21.1.28.2 Precast Concrete Pillars

The precast concrete boundary pillars shall be cast in cement concrete 1:2:4 (1 cement : 2 coarse sand : 4 graded stone aggregate 20mm nominal size), where specified reinforced with 10mm diameter tor steel bars or as directed. The precast concrete pillars shall be finished smooth with 1:3 cement mortars.

The lower half portion of the boundary pillars or as shown and drawings shall be encased on all sides by at least 15 cm of 1:4:8 foundation concrete (1 cement : 4 fine sand : 8 graded stone aggregates of 40mm nominal size). The work shall be carried out fine according to the applicable provisions of Section 5 – Plain & Reinforced Concrete.

21.1.28.3 Hard Stone Boundary Pillars

The hard stone boundary pillars shall be as stated under Clause 21.1.28.1 above. The stone boundary pillars shall be installed as specified for concrete pillars under Clause 21.1.28.2 above.

21.1.28.4 Engraving / Letters

The boundary pillars shall be engraved/written letters for each pillar as specified.

21.1.29 KILLOMETER STONES

21.1.29.1 General

The kilometers stones shall be either precast concrete or of hard durable stone in shape and sizes as specified.

21.1.29.2 Precast Concrete Stones

The precast stones shall be cast in 1:2:4 concrete complying with the provisions of Section 5 – Plain & Reinforced Concrete. 1:3 cement mortars shall be applied for smooth finish. The excavation for foundation as specified for installation shall comply with the provision of Section 3 – Earthwork. The pillar shall be fixed in 1:4:8 concrete of the specified size and backfilled. The letters as specified shall be engraved or painted.

21.1.29.3 Hard Stone Kilometer

The hard stone kilometer shall comply the provisions for boundary stone under Clause 21.28.1 and shall comply with provision of Clause 21.28.3 for installation.

The letters shall be engraved or painted as specified.

21.1.30 CONCRETE KERBS, GUTTERS AND CHANNELS

21.1.30.1 General

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-in-Charge. 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

21.1.30.2 Material Requirements

This concrete for cast in place concrete kerb, gutters and channels shall be as indicated on the Drawings and shall conform to the requirements of Section 5- Plain & Reinforced Concrete.

Precast concrete kerbing units shall consist of 1:3:6 concrete conforming to the Section 5 – Plain & Reinforced Concrete 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.

Form to hold the concrete shall be built and set in place as described under Sub-Section 5 – 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 Section-Section 5.4 – “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 (3) minutes after preparation.

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

21.1.30.3 Construction Requirements

i) **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-in-Charge. Where directed by the Engineer-in-Charge, 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

sheet template referred to above, on the approval of the Engineer in-Charge. 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 of 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 location 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 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 construction 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 be not 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. All surface 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 5.3.7 Curing, Concrete and approved by the Engineer-in-Charge.

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.

ii) **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 the Engineer-in-Charge. Bedding shall consist of 1:3:6 Concrete or as designated in drawings conforming to the

requirements of Section 5 – Plain & Reinforced Concrete 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-in-Charge.

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 under (i) above.

iii) **Extruded Concrete Kerbing and Channels**

a) Excavation and Bedding

Excavation and bedding shall conform to the requirements as described under (i)(a) above.

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 operate under sufficient uniform restraint to forward motion to produce a well 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 guide line.

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 filler with a tight fit. Preformed joint filler shall conform to the provisions of Sub-section 21.1.25.2 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-in-Charge. 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 under (i) and (ii) of this Sub-Section 21.30.3.

21.1.31 REPAIRING ASPHALT BITUMEN ROADS

21.1.31.1 Preparation

The surfaces and portions to be repaired shall be prepared by brushing cleaning cutting and dismantling as specified and directed by the Engineer-in-Charge.

21.1.31.2 Repairing

The surfaces prepared shall be repaired with the original constructions material as specified following the applicable specifications and directed by the Engineer-in-Charge.

21.1.32 REPLACING PIPES

21.1.32.1 EXCAVATION

Excavation of trenches in natural surface and Roads for Laying/Replacing Pipes shall be carried out as shown on drawings in natural surface or roadway in accordance with applicable provisions of Section 3 – Earthwork. Where necessary dismantling shall be done according to applicable provisions of Section 4 – Dismantling.

21.1.32.2 Laying of Pipes

The bed of trenches shall be prepared as specified.

The pipes as designated shall be laid in accordance with applicable provisions of Section 25 – Sewerage& Section 27 – Tube well& Water Supply.

21.2 ROAD STRUCTURES

21.2.1 GENERAL

The following are the major road structures;

- a) Bridges
- b) Culverts

The bridges are dealt with in a Section 10 – Road Bridges. The culverts and curbs are referred hereunder. The culverts are described for various categories. All works shall be constructed according to drawings, specifications and as approved by the Engineer-in-Charge.

21.2.2 SLAB CULVERTS

21.2.2.1 Materials

Cement, fine and coarse aggregates, water and reinforcement steel shall conform to the respective provision of Section 5 – Plain & Reinforced Concrete. The burnt bricks shall conform with the provisions of Section 11 – Brickwork.

21.2.2.2 Excavation

The excavation as required shall conform to the provision of Clause 3.8.4 “Excavation in trenches for pipes cables etc.”

21.2.2.3 Construction Requirements

- a) Laying Cement Concrete in Foundation: It shall be laid in accordance with provisions of Section 5, Plain & Reinforced Concrete and in conformity with the lines, and grades shown on the plan.
- b) The abutment and wing walls shall be constructed in cement mortar in brick masonry, or precast concrete blocks or stone masonry according to the applicable provisions of Section 11 – Brickwork or Section 9 – Block Masonry or Section 12 – Stone Masonry as specified.
- c) Laying Reinforced Cement Concrete Slab: It shall be laid in conformity with the lines shown on the plan and in accordance with the provisions of Section 5 – Plain & Reinforced Concrete.

- d) **Backfilling:**
It shall be done in accordance with Clause 3.8.4 – Earthwork.
- e) **Construction of Parapets:**
These shall be constructed in accordance with the lines and grades shown on the plan and in accordance with the provisions of (b) above.
- f) **Construction of Up-stream and Down-stream toe walls:**
These shall be constructed in accordance with the lines and grades shown on the plan and in accordance with the lines and grade shown on the plan and in accordance with applicable provisions of above referred paras.
- g) **Construction of Floors:**
Bricks on edge flooring in cement mortar shall be laid over cement, concrete in conformity with the lines and grades shown on the plan and in accordance with the provisions of the above referred paras.
- h) **Pre-mix Carpet:**
It shall be laid over RCC Slab as shown on the plan in requisite thickness and in accordance with applicable provisions of Clause 21.1.20 – Asphaltic Concrete Road Mix.
- i) **Plastering:**
½” thick plastering shall be done with cement mortar in accordance with Section 11 – Brickwork and in conformity with the lines shown on the plans.

21.2.3 PIPE CULVERTS

21.2.3.1 Description

This work shall consist of the construction or reconstruction of pipe culverts, hereinafter referred to “conduit” in accordance with these specifications and in conformity with the lines and grades shown on the plans or established by the Engineer-in-Charge.

21.2.3.2 Materials

Materials shall meet the requirements specified as under;

- i) **Cast Iron Pipe:**
This pipe shall conform to RS 78 for spigot and socket vertically cast pipe, RS 1211 for spigot and spun iron pipes and RS 2035 for flanged pipes for the specified diameter weight and thickness.
- ii) **Reinforced Cement Concrete Pipe:**
This pipe shall conform to the requirements of ASTM Designation C-76 for Class-IV pipes “Reinforced Cement Concrete Pipes” for the specified diameter, weight, thickness and reinforcements.
- iii) **Joint Mortar:**
Pipe joint mortar shall consist of one part Portland cement and two parts approved sand with water in accordance with Clause 11.7.2(ii) “Cement Mortar”.

21.2.3.3 Excavation

It shall conform to provisions of Clause 3.8.4.

21.2.3.4 Construction Requirements

- a) **Trenches:**
Trenches shall be excavated to a width sufficient to allow for proper jointing of the conduit and thorough compaction of the bedding and backfill material under and around the conduit. Where feasible, trench walls shall be vertical.

The completed trench bottom shall be firm for its full length and width. Where required, in the case of cross drains, the trench shall have a longitudinal camber of the magnitude specified.

Where conduits are to be placed in embankment fill, the excavation shall be made after the embankment has been completed to the specified height above the designed grade for those conduits specified on the plans.

b) **Bedding:**

The conduit bedding shall conform to one of the classes specified, when no bedding class is specified the requirements for Class "C" bedding shall apply.

Class "A" bedding shall consist of a continuous concrete base conforming to the plan and details.

Class "B" bedding shall consist of bedding conduit to a depth of not less than 30 per cent of the vertical outside diameter of the conduit plus 4 inches. This bedding material shall be sand or selected sandy soil all of which passes a 3/8 inch sieve and not more than 10 per cent passes a No. 200 sieve. The layer of bedding, material shall be shaped to fit the conduit for at least 15 percent of its total height. Recesses in the trench bottom shall be shaped to accommodate the bell when the bell and spigot type conduit is used.

Class "C" bedding shall consist of bedding the conduit to a depth of not less than 10 percent of its total height the bed shall be shaped to fit the conduit and shall have recesses shaped to receive the bell.

c) **Laying Conduit:**

The conduit laying shall begin at the downstream end of the conduit line. The lower segment of the conduit shall be in contact with the shaped bedding throughout its full length. Bell or groove ends of rigid conduits and outside circumferential laps of flexible conduits shall be placed facing upstream. Flexible conduit shall be placed with longitudinal laps at the sides.

c) **Joint Conduit:**

Rigid conduits may be of bell and spigot or tongue and groove design unless one particular type is specified. The method of jointing conduit sections shall be such that ends are fully entered and the inner surfaces are reasonably flush and even.

Joints shall be made with (a) Portland Cement Mortar, (b) Portland Cement Grout, (c) Rubber gaskets or any other type as may be specified.

Mortar joints shall be made with an excess of mortar to form a bead around the outside of the conduit and finished smooth on the inside. For grouted joints, mould or runners shall be used to retain the poured grout. Rubber ring gaskets shall be installed so as to form a flexible watertight seal. When Portland Cement mixtures are used, the completed joint shall be protected against rapid drying by suitable covering material.

Flexible conduits shall be firmly joined by coupling bands. Conduit shall be inspected before any backfill is placed. Any pipe found to be out of alignment, unduly settled, or damaged shall be taken up and re-laid or replaced.

d) **Backfilling:**

After the conduit is installed, the trench shall be backfilled with selected material in accordance with specifications referred above.

When the top of the conduit is exposed above the top of the trench embankment, material shall be placed and compacted for a width on each side of the conduit equal to at least twice the horizontal inside diameter of the conduit, or as shown on drawings. The embankment on each side of the conduit, for a distance equal to the horizontal inside diameter of the conduit, shall be of the same material and compacted in the manner described for backfilling. The remainder of the fill material shall not contain frozen lumps, stone in excess of 3 inch diameter, or other objectionable material. Compaction shall be achieved as provided for backfill or by rolling. The embankment shall be

placed and compacted simultaneously on both sides of the conduit for the full width of the road bed upto an elevation one foot above the top of the conduit. Above this elevation the embankment shall be placed and compacted in normal manner, except where the imperfect trench method is prescribed.

e) **Imperfect Trench:**

Under this method, for rigid conduit, the embankment shall be completed as described above, to a height above the conduit equal to vertical outside diameter of the conduit plus one foot. A trench equal in width to the outside horizontal diameter of the conduit shall then be excavated to within one foot of the top of the conduit, trench walls being as nearly vertical as possible. The trench shall be loosely filled with highly compactable soil, straw, hay, corn, stalks, leaves, brush or sawdust may be used to fill the lower $\frac{1}{4}$ to $\frac{1}{3}$ of the trench. Construction of embankment above shall then proceed in a normal manner.

21.3 ASPHALT CONCRETE AND CEMENT CONCRETE SIDEWALK

21.3.1 GENERAL

This work shall consist of the construction of sidewalks which can be asphalt concrete, plain Portland cement concrete, or precast Portland cement concrete slabs (450x450) mm or smaller or interlocking concrete blocks all in accordance with these specifications and to the line, grade, levels and dimensions shown on the Drawings or as required by the Engineer-in-Charge.

21.3.2 MATERIAL REQUIREMENTS

a) Cement Concrete

The concrete shall be either 1:3:6 or 1:2:4 as indicated on the drawings and in accordance with Section 5 – Plain & Reinforced Concrete.

b) Asphalt Concrete

Asphaltic concrete shall conform to the requirements of Sub-Section 21.1.24 – Asphalt Concrete Wearing Course.

c) Expansion Joint Filler

Unless otherwise directed the joint filler shall have a thickness of five (5) mm and conform to the requirements of Sub-Section 21.1.30.2.

d) Forms

Forms shall be of wood or metal as approved by the Engineer-in-Charge and shall extend to the full depth of the concrete. All forms shall be straight, free from warp and of adequate strength to resist bending.

e) Bed Course Material

Bed course material shall consist of sand, slag, gravel, crushed stone or other approved materials of such gradation that all particles will pass through a $\frac{1}{2}$ " (12.5mm) sieve.

f) Asphaltic Prime Coat

Asphaltic prime coat material shall conform to the requirements of Sub-Section 21.1.18.3 for Cut-back Asphalt.

21.3.3 CONSTRUCTION REQUIREMENTS

21.3.3.1 Asphalt Concrete Sidewalk

a) Excavation

Excavation shall be made to the required depth and to a width that will permit the installation and bracing of the forms. The foundation shall be shaped and compacted to minimum ninety(90) percent of the maximum dry density as determined by AASHTO T-191 Method. The surface shall

be even conforming to the section shown on the drawings. All soft material shall be removed and replaced with acceptable materials.

b) Placing of Bed Course Material

The bed course material shall be compacted in layers not exceeding ten (10) cm to the depth shown on the drawings and to the line and grade of the finished sidewalk surface.

c) Priming the Bed Course Material

The prepared bed course material shall received an application of prime coat in accordance with the requirements of Item 21.1.7 and approved by the Engineer-in-Charge.

d) Placing the Asphalt Concrete

The asphalt concrete shall be placed on the previously primed prepared bed only when, in the opinion of the Engineer-in-Charge the bed is sufficiently dry and weather conditions are suitable. The mixture shall be placed on one or more course of uniform thickness as shown on the Drawings. Each course shall be smoothed by raking or screeding and shall be thoroughly compacted by rolling with a hand operated roller or a type satisfactory to the Engineer-in-Charge. After compaction, the surfacing shall be of the thickness and section shown on the Drawings, shall be smooth even and of a dense and uniform texture. Forms, if used, shall be removed and the shoulders shaped and compacted to the required section.

21.3.3.2 Cement Concrete Sidewalk

a) Excavation

Excavation shall meet the requirements of Sub-Section 21.3.3.1(a).

b) Placing of Bed Course Material

Where indicated on the drawings the bed course material shall be placed in accordance with Sub-Section 21.3.3.1(b).

c) Forms and Expansion Joints

All forms shall be staked securely in position at the correct line and elevation. Expansion joint filler shall be set in the position shown on the Drawings before the placing of the concrete is started. The joint filler shall be placed 5mm below the top surface of the finished sidewalk.

d) Placing the Cement Concrete Material

The mixing, placing, finishing and curing of concrete shall be as provided in Section 5 – Plain & Reinforced Concrete.

Before the concrete has set, the surface of the concrete shall be trowled until it is of uniform smoothness and is true to the lines, elevations and surface required.

The surface shall be cut through to a depth of one(1) cm with a trowel at intervals of one(1) meter or where required, in straight lines perpendicular to the edge of the sidewalk. The surface shall then be brushed. The edges of the sidewalk and the transverse cuts shall be shaped with a suitable tool so formed as to round the edges to a one and half (1.5) centimeters radius.

e) Precast Elements

Precast concrete slabs or interlocking concrete blocks shall be set on the bed course materials where indicated on the drawings or as directed by the Engineer-in-Charge to provide a smooth top surface without ridges or lumps at joints.

Precast concrete units shall be fair faced cast to the sizes and dimensions as indicated on the drawings.

The concrete used for pre-cast unit shall conform to the specifications laid down in Sub-Section 5 - Plain & Reinforced Concrete. The Contractor shall be required to submit a sample of pre-cast unit for the approval of the Engineer-in-Charge. All pre-cast units shall strictly conform to the approved sample.

A pre-cast unit cracked or damaged before, during or after erection shall be removed from the works and replaced by the Contractor at his own expense. All pre-cast units shall be smoothly finished to the required lines, grades angles etc. Holes, grooves, pockets, hooks shall be provided as shown or as directed by the Engineer-in-Charge.

The units shall be properly stacked on a platform without causing any cracks of damage. Curing of all the pre-cast units shall be done in accordance with Sub-Section 5.3.7. – Plain & Reinforced Concrete.

21.4 BRICK EDGING

21.4.1 GENERAL

This work shall consist of brick installed on vertical edge between the pavement structure and shoulders in such a manner that the brick is laid on compacted shoulders and top of brick is flushed with the slope of road pavement.

21.4.2 MATERIAL REQUIREMENTS

a) Bricks

Quality of Bricks shall meet the material requirement as specified in Section 11 – Brickwork.

b) Construction Requirements

A trench of appropriate dimensions shall be excavated to accommodate brick on vertical edge so that top of the brick becomes flushed with the top of road pavement and to ensure that one face of the brick remains in contact with the pavement structure. The cavities on the other face of the brick shall be refilled with the excavated shoulder material and properly compacted. The brick shall be laid in accordance with the line and grade of the road pavement. It shall be ensured that bricks are installed in vertical positions.

21.5 TRAFFIC ROAD SIGNS AND SAFETY DEVICES

21.5.1 GENERAL

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

21.5.2 MATERIAL REQUIREMENTS

1. Sign Panels

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

The blanks shall be free from laminations, blisters, open seams, pits, holes, or other defects that may affect their appearance or use. The thickness shall be uniform and the blank commercially flat. Perform shearing, cutting and punching before preparing the blanks for application of reflective material. The blanks shall be cleaned, degreased and chromate or otherwise properly prepared according to methods recommended by the sheeting manufacturer.

2. Reflective Sheeting

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

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

The manufacturer of the sheeting being offered shall furnish the process inks, clears and thinners produced by the sheeting manufacturer recommended for and compatible with the sheeting to meet the performance requirements of this specification and shall further be responsible for technical assistance in the use of these inks or alternatively sheeting can be used on sheeting. The sheeting manufacturer must provide documented evidence to the satisfaction of the Engineer-in-Charge that representative production materials of the type to be supplied has been used successfully in a substantial traffic signing program in similar climatic conditions for at least three years.

a) Color Requirements

Color shall be specified and conform to the requirements of Table 21.5(a).

**Table 21.5 (a)
Color Specification Limits* and Reference Standards**

Color	X	Y	X	Y	X	Y	X	Y	Reflectance		
									Limit Min.	(Y) Max.	Munsell** Paper
White	.303	.287	.368	.353	.340	.380	.274	.316	27.0		5PB 7/1
Yellow	.498	.412	.557	.442	.479	.520	.438	.472	15.0	40.0	1.25Y 6/12
Red	.613	.297	.708	.292	.636	.364	.558	.352	2.5	11.0	7.5R 3/12
Blue	.144	.030	.244	.202	.190	.247	.066	.208	1.0	10.0	5.8PB 1.32/6.8
Orange	.550	.360	.630	.370	.581	.418	.516	.394	14.0	30.0	2.5YR 5.5/14
Brown	.430	.340	.430	.390	.550	.450	.610	.390	3.0	9.0	5YR 3.6
Green	.30	.380	.166	.346	.286	.4288	.201	.776	3.0	8.0	10G 3/8

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

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

b) Coefficient of Retro-reflection

The coefficients of retro-reflection shall conform to the minimum requirements of Table 21.5(b).

Table 21.5(b)

**Minimum Coefficient of Retro-reflection
(Candelas per Foot-candle per Square Foot)**

Observation Angle ^o	Entrance Angle ^o	White	Red	Yellow	Green	Blue	Brown	Orange
0.2	-4	250	45	170	45	20.0	12.0	100.0
0.2	+30	150	25	100	25	11.0	8.5	60.0
0.5	-4	95	15	62	15	7.5	5.0	30.0
0.5	+30	65	10	45	10	5.0	3.5	25.0

For screen printed transparent colored areas on white sheeting, the coefficients of retro-reflection shall not be less than 70% of the values for corresponding color in the above table.

The sheeting manufacturer unless otherwise approved shall provide a test report from a recognized laboratory stating that the sheeting meets the requirements according to BSI-873 Part 6, or FP-92 of FHWA. The brightness of the reflective sheeting totally wet by rain, shall be at least ninety (90) % of the above value.

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

The sheeting shall show no cracking or reduction in reflection after being subjected to the dropping of a twenty five (25) mm diameter steel ball from a height of two (2) meters onto its surface. For heat activated material the adhesive shall permit the reflective sheeting to adhere securely forty eight (48) hours after application, at temperatures of up to ninety (90) degree centigrade.

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

c) Performance Requirements and Obligation

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

Sheetings processed and applied to sign blank materials in accordance with sheeting manufacturer's recommendation, shall perform effectively for the number of years stated in Table-21.5(c) of this specification. The retro-reflective sheeting will be considered unsatisfactory if it has deteriorated due to natural causes to the extent that; (1) the sign is ineffective for its intended purpose when viewed from a moving vehicle under normal day and night driving conditions; or (2) the coefficient of retro-reflection is less than the minimum specified for sheeting during that period listed in Table 21.5(c).

Table 21.5(c)
Minimum Coefficient of Retro-reflection Candelas per Foot
Candle per Square Foot (.2" OBS, and -4° Entrance)*

Sheeting Color	Minimum Coefficient of Retro-reflection (7 Years)	Minimum Coefficient of Retro-reflection (10 Years)
White	212	200
Yellow	144	136
Green	38	36
Red	38	36
Blue	17	16
Brown	10	9

For screen printed transparent coloured areas on white sheeting, the coefficients of retro-reflection shall not be less than 50% of the values for the corresponding colour in the above table. All measurements shall be made after sign cleaning according to sheeting manufacturer's recommendations.

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

- a) The entire seven years the signs manufacturer and sheeting manufacturer will replace the sheeting required to restore the sign surface to its original effectiveness.
- b) In addition, during the first five years sign manufacturer and sheeting manufacturer will cover the cost of restoring the sign surface to its original effectiveness at no cost to the Client for materials and labor. Samples of the reflective sheeting shall be approved by the Engineer-in-Charge prior to the Contractor placing his order.

3. Metal Posts

Wide flange of 10x10 centimetres metal posts shall be fabricated from structural steel conforming to the Specifications of ASTM A-283 Grade-D. In lieu of wide flange steel posts the Contractor may use tubular steel posts of minimum internal and external diameters of sixty three (63)mm and seventy five (75)mm respectively conforming to the specifications of ASTM A-501.

All posts shall be thoroughly cleaned, free from grease, scale and rust, and shall be given one coat of rust inhibitive, priming paint and two coats of grey paint. Length of the posts shall be such that their top flushes with the top of the sign panel, whereas bottom of sign panel is at least hundred and eighty (180) centimetres above shoulder level.

4. Plates

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

It shall be so cut that there are no sharp edges and that the corners are rounded off to a radius of thirty seven and half (37.50)mm. Any trade mark or other printing shall be carefully removed with liquid thinner.

- b) The High Intensity Grade sheeting for the background should cover the whole area of the sign plate.

- c) Prior to application of the High Intensity Grade reflective sheeting, the sign plate shall be cleaned and shall be wax-free. They shall be degreased by vapour or by alkaline immersion and etched by scrubbing with abrasive cleaner. The plate shall be rinsed thoroughly and dried with hot air before applying the sheets.
 - d) The sheeting after application to the sign base shall not come off the edges, which shall be sealed, nor shall it peel off nor warp. The surface shall be smooth and free from any bubbles, Pimples, edge chipping or edge shattering. It shall be washable and weather-proof.
5. Nuts and Bolts
- All Nuts and bolts and metal washers shall be of heavily galvanized quality ten (10)mm dia. (G.I) or aluminium alloy. They bolt heads to be such that they do not protrude out too much nor show very much on the front face of the plate. The heads should be flush with the plate face and covered with sheeting galvanized according to ASTM A-153.
6. Rubber Washer
- All rubber washers shall have thick walls and shall not get dry and brittle when exposed to weather at the site after they are in position during the life of the sign.
7. Caps over the pipes
- These can be heavy plastic or of aluminium well fitted so that they cannot be removed any good adhesive can be used.
8. General
- a) Very large signs need not be made of one piece; in that case extended Aluminium panels shall be used or the various pieces of sheet shall be joined by angle-irons in anti corodal materials, and, if necessary, with connecting cross pieces in order to ensure the solidity of the joint and with slanting struts embedded In the concrete as directed by the Engineer-in-Charge.
 - b) All the nuts and bolts and metal washers must be heavily galvanized, or may be of stainless steel of high quality.
 - c) Relevant holes to receive 10mm bolts shall be drilled into the pipes and the plates and not punched. These to be drilled through the plates before the application of scotchlite.
 - d) After the plates are fixed with nuts and bolts, the nuts shall be TACK WELDED to the bolts against pilferage.
9. Concrete Foundation Blocks
- The concrete for the foundation blocks shall be in situ 1:3:6 concrete in accordance Section 5, Plain & Reinforced Concrete and shall of the size 450x450x650mm for category 1 & 2 and 600x600x750mm for category 3.
10. Road Posts and Hazard Markers
- The road posts and hazard markers used as permanent safety devices shall conform fully with the requirements of the statutory instruments, current British standards and chapter four of the Traffic signs manual. The safety devices shall consist of delineators and detours of verge master, flex master, edge master, passing place post and chevron-flex etc. and will be manufactured from highly durable tough plastic material with standing vehicular impact. These shall be a High Intensity Grade reflective sheeting for maximum visibility by both day and night and consequently be resistant to impact, damage and vandalism.

21.5.3 CONSTRUCTION REQUIREMENTS

1. Excavation and Backfilling

Holes shall be excavated to the required depth of the bottom of the concrete foundation as shown on the Drawings. Backfilling shall be carried out by using the surplus excavated material if approved by the Engineer-in-Charge and shall be compacted in layers not exceeding fifteen (15) cm in depth.

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

2. Erection of Posts

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

3. Sign Panel Installation

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

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

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

4. Categories of Signs

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

a. Warning Signs

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

b. Regulatory Signs

Constructed with single post and sign of circular shape, as shown in the drawings, category 2.

c. Informatory Signs

These signs shall be rectangular in shape and constructed with one, two or three numbers of posts or as shown on the drawings. Dimensions may vary according to the requirements, however total area of sign shall be as under:

Category 3 a	= One sq. meter
Category 3 b	= Two sq. meter
Category 3 c	= As shown on drawings

d. Additional panel

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

5. Installation of Safety Devices

Safety devices comprising of road posts, delineators of various types, fixed/portable safety barriers and hazard markers e.g. verge-master, flex-master chevron-flex, big-max, edge-master and passing place post and other etc., shall be installed in accordance with the techniques and methods

laid down in the manufacturer's manual or guide and in conformity to the line and level and locations shown on the drawings or as directed by the Engineer-in-Charge to ensure maximum visibility and safety, even in adverse weather conditions. These shall be constructed strictly with the specifications and full assistance by the manufacturer for installation with precision. These safety devices shall be used as delineators at sharp curves of highways verges, high embankments, culverts, bridges, as a visual and physical deterrent for a prohibiting car parking on grass verges and protecting kerb-side areas on public and private roads.

6. Sign Faces

a) Design

All sign faces shall be of the type, colour, design and size as shown in the plans. Size and spacing of letters shall be as under;

1. The Urdu writing shall be in "Persian" character.
2. The Urdu and English writing shall be about the same in length width and spacing.
3. English letters are to be in italics except the first letter of the word, which is to be in capital
4. Height of Capital letters 21 cm
5. Height of italics letters 17 cm
6. Stroke Width and Width of border 3.5 cm
7. Space between words and border (at least) 5 cm
8. Space between words 5 cm
9. Space one line will occupy 4 cm
10. Space between digits of numerals 4 cm
11. Height of numerals same as capital letters 23 cm
12. Space between lines (at least) 5 cm
13. Size of letter for km. height K-23cm 8 cm
14. Width of letters for km including spacing K-8 cm - 9.6 cm
15. Width of dividing line
16. The size and spacing for Urdu letter and Word will generally conform to the dimensions shown above for English letters
17. The spelling of place names in Urdu and in English shall be as written in the Survey of Pakistan maps

b) Shop Drawings

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

7. Storage of Signs

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

21.6 PAVEMENT MARKING

21.6.1 GENERAL

This work shall consist of furnishing non reflective or reflective chlorinated rubber based or thermoplastic paint material or retro-reflective preformed pavement marking (tape) as specified for sampling and packing, for the preparation of the surface and for the application of the paint to the pavement surface all in accordance with these Specifications. The paint shall be applied in conformance to the size, shape and location of the markings as shown in the Drawings.

21.6.2 CHLORINATED RUBBER PAINT

1. Material Requirements

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

a) White Traffic Paint - Composition

1.	Pigment	Titanium Dioxide Rutile & extenders	100%
2.	Vehicle	Modified Chlorinated Rubber Plasticized and Resin Blend	52 ± 4%
		Solvents	45 ± 4%
		Additives i.e. flow leveling, adhesion improving agents, anti-oxidants, siccatives etc.	1 - 3%
3.	Paint Composition	Pigments	55 ± 4% by wt.
		Vehicle Solvent and Additives	45 ± 5% by wt.

b) White Traffic Paint

1.	Pigment	Chrome Yellow and Extenders	100% by wt.
2.	Vehicle	Same as for white traffic paint	
3.	Paint Composition	Pigments	55 ± 4% by wt.
		Vehicle Solvent and Additives	45 ± 5% by wt.

c) Block Traffic Paint

1.	Pigment	Chrome Yellow and Extenders	100% by wt.
2.	Vehicle	Same as for white traffic paint	
3.	Paint Composition	Pigments	55 ± 4% by wt.
		Vehicle	45 ± 5% by wt.

The volatile material shall be of such character that has a minimum solvent action of asphalt and such that the resins and non-volatile components will be entirely dissolved in the volatile material and will not precipitate from the solution on standing. The non-volatile material shall be of such quality that it will not darken or become yellow when a thin section is exposed to the sunlight.

Other pavement marking paint may be submitted by the Contractor as an alternative to the above, for the approval of the Engineer-in-Charge.

2. Ballotini for Reflective Road Paint

The grading of ballotini dispersed in the paint shall be as follows:

Sieve Sizes	Percentage Retained
No. 12	0
No. 20	30
No. 30	50
No. 50	80
No. 80	100

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

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

3. Photometric Requirements for Reflective Road Paint

Other reflective road paints may be considered for use by the Engineer-in-Charge provided they have minimum brightness values at two tenth (0.2) degree and half (0.5) degree divergence expressed as candle power per meter per square meter of surface coating as follows:

		White		Yellow	
		0.2	0.5	0.2	0.5
Divergence Angle	(Degree)	237	118	129	75
Incidence Angles	4 (Degree)	75	43	43	32
Incidence Angles	40 (Degree)				

Construction Requirements

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

The painting of lane markers and traffic strips and include the cleaning of the pavement surface, the application, protection and drying of the paint coatings, the protection of pedestrians, vehicular or other traffic on the pavements, the protection of all parts of the road, structures or appurtenances against disfigurement by spatters, splashes or smirches of paint or of paint materials, and the supplying of all tools, labour and traffic paint necessary for the entire work. The paint shall not be applied during rain, wet weather when the air is misty, or when in the opinion of the Engineer-in-Charge, conditions are otherwise unfavourable for the work. Paint shall not be applied upon damp pavement surfaces, or upon pavements which have absorbed heat sufficient to cause the paint to blister and produce a porous paint film.

The application of paint shall preferably be carried out by a purpose-made machine but where brushes are used only round or over brushes not exceeding 10 cm in width will be permitted. The paint, when applied, shall be so applied as to produce a uniform, even coating in close contact with the surface being painted. Traffic paint shall be applied to the pavement at a rate of one(1) litre to two and half (2.5) square meters or less. Contractor shall provide adequate arrangements that applied paint is not disfigured by moving traffic, till its complete drying and sticking to road surface.

21.6.3 HOT- APPLIED THERMOPLASTIC ROAD PAINTS

21.6.3.1 Material Requirements

1. Aggregate
The aggregate shall consist of light coloured silica sand, calcite, quartz, calcined flint, or other material approved by the Engineer-in-Charge.
2. Pigment and Extender
 - a) White Material
The pigment shall be titanium dioxide complying with the requirements of Type-A (anatase) or Type-R (rutile) of BS-1851.
 - b) Yellow Material
Sufficient suitable yellow pigment shall be substituted for all or part of the titanium dioxide to comply with the other requirements of this specification.
 - c) All Material
The extender shall normally be whiting (i.e. calcium carbonate prepared from natural chalk) complying with the requirements of BS-1795. The manufacturer may substitute lithopone complying with the requirement of BS 296 for any or all of the whiting.
 - d) Binder
The binder shall consist of synthetic hydrocarbon resin, or, with the approval of the Engineer-in-Charge, gun or wood resin, plasticized with mineral oil.
 - e) Composition of Mixture
The proportions of the constituents of the mixed material as found on analysis shall comply with the requirements of Table 21.6(a).

Table 21.6(a)
Proportions of Constituents of Mixture

Constituent	Percentage by mass of total mixture	
	Minimum	Maximum
Binder (resin and oil)	18	22
Pigment	6*	-
Pigment and extender	18	22
Ballotini	20	-
Aggregate		
Pigment	78	82
Extender and ballotini		

*For titanium dioxide only. No minimum is specified for yellow material.

Where specified, 10% in the case of material to which surface ballotini is to be applied by pressure application.

The grading of the combined aggregate, pigment, extender and ballotine (where specified) as found on analysis shall comply with the requirements of Table 21.6(b).

Table 21.6(b)
Grading of Combined Aggregate, Pigment, Extender and Ballotini

Sieve	Percentage by mass passing Sprayed
2.80 mm	100
600 µm	75-95

21.6.4 SAMPLING AND TESTING

1. Sampling

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

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

2. Testing

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

- Softening Point
The softening point measured in accordance with Appendix C shall be not less than 65°C.
- Colour and luminance

a) White Material

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

b) Yellow Material

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

- Heat Stability

a) White Material

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

b) Yellow Material

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

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

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

21.6.5 MANUFACTURING, PACKING AND STORING OF PAINT

1. Manufacturing

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

2. Packing

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

3. Storing

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

4. Certification

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

5. Application of Material to the Road

a) Preparation of Site

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

b) Preparation of Material on Site

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

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

c) Laying

Carriageway centre lines, lane lines and edge lines shall be laid to a regular alignment by self propelled machine. Other markings may be laid by hand, hand propelled machine or self propelled machine as approved by the Engineer-in-Charge. The Surface produced shall be uniform in texture and thickness and appreciably free from blisters and streaks.

d) Re-lectorization by Surface Application

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

Ballotini dispensed on the surface of the markings shall conform to the following grading:

Sieve	Percentage by mass passing
1.7 mm	100
600 μ	80 – 100
425 μ	45 – 100
300 μ	10 – 45
212 μ	0 – 25
75 μ	0 – 5

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

e) Thickness

Unless otherwise approved by the Engineer-in-Charge, the material shall belaid to the following thicknesses.

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

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

6. Trial Section

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

21.6.6 RETROREFLECTIVE PREFORMED PAVEMENT MARKINGS

1. Materials Requirements

The performed markings shall consist of white or yellow films with pigments selected to conform to standard highway colours. Ceramic and glass beads shall be incorporated to provide immediate and continuing retro-reflection. Ceramic skid particles shall be bonded to a top urethane layer to provide a skid resistant surface.

The preformed markings shall be capable of being adhered to asphalt cement concrete (ACC) or Portland Cement Concrete (PCC) by a pre-coated pressure sensitive adhesive. A primer may be used to precondition the pavement surface. The preformed marking film shall mold itself to

pavement contours by the action of traffic. The pavement marking film wearing courses during the paving operation in accordance with the manufacturer's instructions, approved by the Engineer-in-Charge. Following proper application and tamping the markings shall be immediately ready for traffic. The bidder, when bidding, shall identify proper solvents and/or primers (where necessary) for proper application and recommendation for application that will assure effective product performance. The preformed markings shall be suitable for use for one year after the date of receipt when stored in accordance with the manufacturer's recommendations.

The marking film shall be durable retro-reflective plisot polymer pavement marking film for performed longitudinal markings subject to low to medium traffic volumes and moderate wear conditions such as repeated shear action from crossover or encroachment on channelization lines.

The retro reflective pavement marking film shall consist of mixture of high quality pigmented polymeric material, with a reflective layer of ceramic and glass beads and a layer of skid resistant ceramic particles bonded to the top urethane wear surface. The film shall have a pre-coated pressure sensitive adhesive. The edges of the preformed tape shall be clear cut and true.

2. Colour

The daytime colour of the white film shall provide a minimum initial Luminance factor, Y of 80 and shall conform to the following chromaticity requirements:

$$X = 0.290, Y = 0.315; X = 0.491, Y = 0.435; X = 0.512, Y = 0.486; X = 0.536, Y = 0.463.$$

Measurements shall be made in accordance with ASTM E-1349, using illuminant "C" and 0/45 (45/0) geometry, Calculations shall be in accordance with ASTM E-308 for the 2° standard observer.

3. Reflectance

The white and yellow films shall have the following initial minimum reflectance values as measured in accordance with the testing procedures of ASTM D-4061. The photometric quantity to be measured shall be specific luminance (SL), and shall be expressed as millicandals per square foot per foot-candle (mcd. ft², fc⁻¹). The metric equivalent shall be expressed as millicandals per square meter per lux (mcd. m⁻², lx⁻¹).

Description	White	Yellow
Entrance Angle 86.00°	86.5°	86.5°
Observation Angle	1.0°	1.0°
Specific Luminance SL [(mcd. ft ²), fc ⁻¹]	300	175

4. Skid Resistance

The surface of the retro-reflective films shall provide an initial minimum skid resistance values of 55 BPN as measured by British Portable Skid Tester in accordance with ASTM E-303.

5. Patch ability

The pavement marking film shall be capable of use for patching worn areas of the same type of film in accordance with the manufacturer's instructions.

6. Reflectance Retention

To have a good, effective performance life the ceramic and glass beads must be strongly bonded and not be easily removed by traffic wear. The following test shall be employed to measured reflectivity retention.

7. Taber Abraser Simulation Test

Using a Taber Abraser with an H-18 wheel and a 125 gram load, the sample shall be inspected at 200 cycles, under a microscope, to observed the extend and type of bead failure. No more than 15% of the beads shall be lost due to pop-out and the predominant mode of failure shall be “wear down” on the beads.

8. Beads

The size, quality and refractive index of the ceramic and glass beads shall be such that the performance requirements for the marking shall be met. The bead adhesion shall be such that beads are not easily removed when the material surface is scratched.

9. Bead Retention

The film shall be ceramic and glass bead retention qualities such that when a 2”x6” (5.08cm x 15.24cm) sample is bend over a ½ inch (1.27 cm) diameter-mandrel, with the 2 inch dimension perpendicular to the mandrel axis, microscopic, examination of the area on the mandrel shall show no more than 10% of the beads with entrapment by the binder of less than 40%.

10. Thickness

The film without adhesive shall have a minimum thickness of 0.030 inch (0.76mm).

11. Effective Performance Life

The film, when applied according to the recommendations of the manufacturer, shall provide neat, durable marking that will not flow or distort due to temperature if the pavement surface remains stable. The film shall be weather resistant and through normal traffic wear shall show no fading, lifting or shrinkage which will significantly impair the intended usage of the marking throughout its useful life and shall show no significant tearing, roll back or other signs of poor adhesion.

12. Installation

The markings shall be applied in accordance with the manufacturer’s instructions.

21.6.7 CEMENTITIOUS MARKING COMPOUND

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

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

21.7 REFLECTORIZED PAVEMENT STUDS

21.7.1 GENERAL

The work shall consist of furnishing and installing reflectORIZED pavement studs set into the travelled way of the type in accordance with the specifications and at the locations shown on the Drawings or as directed by the Engineer-in-Charge.

21.7.2 MATERIAL REQUIREMENTS

1. Reflectorized Studs

Reflectorized studs shall be “cat-eyes” either the ‘Flush Surface’ type fo Raised Profile type having the following characteristics.

a) ‘Flush Surface’ Type

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

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

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

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

b) ‘Raised Profile’ Type

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

The shall contain one or two prismatic reflector each inclined at an angle of thirty(30) degree to the horizontal and having an area not less than twenty(20) square cm or as indicated on the plans. The reflectors shall attain the following standards for their photometric and physical qualities:

i) Photometric Requirements

The reflectors shall have the following minimum specific intensity values (S.I) expressed as candle power per foot candle of illumination at the reflector on a plane perpendicular to the incident light.

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

The reflector for testing shall be located with the center of the reflecting face at a distance of one and half (1.5m) from a uniformly bright light source having an effective diameter of half (0.5) centimetre. The width of the photocell shall be 1.27 cms and hslil be shielded from stray light. The distance from the centers of thelight source and photocell shall be 0.53 cms.

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

ii) Strength Requirements

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

A reflector shall be centered horizontally over the open end of a vertically positioned hollow metal cylinder 75 mm internal diameter, 25 mm high and wall thickness of 6 mm. The load shall be

applied to the top of the reflector through a 6mm diameter by 6mm high metal plug centered on top of the reflector.

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

2. Adhesive

When 'Raised Profile' types of reflectors are used, a two part adhesive having the following ingredients shall be applied to the stud for bonding to the pavement surface.

Package A	Kg/Liter
Epoxy Resin	0.94
Titanium Dioxide	0.07
Colloidal Silica	0.05
Talc	0.345
Package B	Kg/Litre
Modified Asphaltic Amine	0.24
Modified Asphaltic Amine	0.472
Carbon Black	0.0022
Colloidal Silica	0.04
Talc	0.650

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

3. Cement Mortar

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

21.7.3 CONSTRUCTION REQUIREMENTS

1. Flush Surface Type

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

Cavities in the pavement shall be clearly cut to the dimension of the pavement stud and shall allow a clearance of one(1) cm around the stud base. The longitudinal center line axis of the cavity shall be the same as that required for the pavement study when laid to correct line and direction. The walls of the cavity shall be splayed back at an angle of approximately thirty(30) degree to the vertical to facilitate a "dove-tail" joint after the mortar has set.

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

The depth of cavity shall be such that when the stud base and reflectors have been installed the elevation of the floor of the lens socket shall not be greater than two(2) mm or less than one mm above the pavement surface.

The stud shall be grouted into position with asphalt concrete containing fine aggregate only or with a cement mortar as described in Sub-Section 21.7.2(3) above when the studs are installed into a cement concrete pavement.

2. Raised Profile Type

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

21.8 DEEP PATCHING

21.8.1 GENERAL

This work shall be carried out in patches of roads where the existing road base material has moved and is lying in loose condition. Requirement under this item is to remove the existing road base and to strengthen it to take new layer of aggregate or water bound macadam base.

21.8.2 MATERIAL REQUIREMENTS

Fresh aggregate base or water bound macadam base may be required to be added to existing road base. Specification for such material shall conform to materials requirements of Sub-Section 21.1.11.2 or 21.1.12.2.

21.8.3 CONSTRUCTION REQUIREMENTS

Patches of roads in which surface courses have broken and road base has moved, the material which has lost its compaction shall be removed. Next layer shall be watered and compacted, thereby the removed material shall be placed back duly screened to remove plastic contamination, by hand picking and passing through sieve No.4 after properly watering and mixing. Material will be re-compacted in layers not exceeding fifteen (15) cms (6 inches) thick with approved equipments. Additional material will be added, if needed particularly non-plastic fines passing sieve No.4.

21.9 IMPROVED SUBGRADE

21.9.1 DESCRIPTION

This work shall consist of the formation of the roadbed, under sub-base or base course as the case may be, with an approved blend of materials, uniformly mixed, compacted, shaped and finished to the lines, grades and typical cross-sections shown on the Drawings, or in thickness as directed by the Engineer-in-charge .

Improved sub-grade as herein referred to may be defined as material suitable for embankment to which better quality of material is blended improper proportion to improve its strength properties or performance.

21.9.2 MATERIAL REQUIREMENTS

The major component of improved sub-grade shall consist of material conforming 21.1.8. The blending material shall be any soil that classifies as A-1(a), A-1(b), A- 2-4 or A-3 according to AA~HTO M-145 with PI of not more than 6.

The blended mixture when compacted to ninety five (95) percent of the maximum dry density determined by AASHTO T 180-0 Method, shall exhibit a laboratory soaked CBR (96 hours) of not less than 20, or as specified in the drawings.

21.9.3 CONSTRUCTION REQUIREMENTS

21.9.3.1 Preparation

The surface of the roadbed on which the improved sub-grade is to be constructed shall be compacted to the density specified under 21.1.8.3(a).

21.9.3.2 Proportioning of Materials

Prior to start of construction, the proportion of each material to be incorporated for improved sub-grade shall be established as approved by the Engineer. The Engineer shall specify a single percentage of each material to be blended' and shall establish. the gradation of the resulting

mixtures along with the ranges of permissible gradation tolerances to obtain the required CBR for the improved sub-grade.

The blend proportions thus established shall apply only when each material to be used is obtained from same source. Should a change in source of material be made, a new proportion shall be established. When unsatisfactory results or other conditions make it necessary, the Engineer-in-charge may require additional laboratory tests.

21.9.3.3 Mixing and Spreading

Improved sub-grade may be constructed with any combination of machines or equipment that will yield results meeting these specifications.

a) Stationary Plant Method

The soil ingredients and water shall be 'mixed in an approved mixing plant (Pug Mill). The plant shall be equipped with feeding and metering devices that will add the materials to be blended in the specified quantities. Water shall be added during the mixing operation in the quantity required for proper compaction, which is approximately optimum moisture content plus or minus two (2) percent. The mixing time shall be that which is required to secure a uniform mixture. After mixing, the blended material shall be transported to the job site while it contains the sufficient moisture and shall be placed on the roadbed by means of an approved mechanical spreader. The mixture shall be spread at rate that will produce' a uniform compacted thickness conforming to the required grade and cross-section. Compaction shall start as soon as possible 'after spreading and shall continue until the specified relative compaction is achieved.

b) Travelling Plant Method

The travelling plant shall be either a flat transverse shaft type or a windrow type pug-mill. After the materials have been placed by a mechanical spreader or windrow sizing device the materials shall be uniformly" mixed by the travelling mixing plant. During the mixing operation, water shall be added as necessary to bring the moisture content of the mixture to the percentage suitable for proper compaction

c) Road Mix Method

The materials shall be transported to the site and spread in layers on the roadbed in the quantities required .to produce the specified blend. After the materials for each lift have been spread. The materials shall be mixed by motor graders and other approved equipment until the mixture is uniform throughout. During mixing operation, water shall be added as necessary to bring the moisture content to the proper percentage

21.9.3.4 Compaction

Unless otherwise permitted by the Engineer based on the performance of the compacting equipment used as determined from the trial section each layer of improved sub-grade shall be placed in horizontal layers of uniform loose thickness not exceeding twenty (20) centimetres. Each layer shall be compacted to the density conforming to the requirements specified 21.1.8.3(a).

In-place density determinations of 'the compacted layers shall be made in accordance with MSHTO T-191, T-238 or other approved methods.

21.9.3.5 Trial Sections

Prior to the formation of the improved sub-grade, the Contractor shall construct three trial sections of 200 meter length one (1) for each blend of improved material proposed to be incorporated for improved sub-grade, or as directed by the Engineer. The compacting equipment to be used in the trial sections shall be the same equipment that the Contractor intends to use for main work, accepted by the Engineer.

The object of these trials is to determine the proper moisture content, the relationship between the number of passes of compacting equipment, density obtained for the blended material, and to establish the optimum lift thickness that can be effectively compacted with the equipment used. No separate payment will be made for this work, which will be regarded as a subsidiary obligation of the Contractor under pay Item No. 110.

21.9.3.6 Protection of Completed Work

Any part of the completed improved sub-grade shall be protected and well drained and any damage 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 improved sub-grade. He shall repair any ruts or ridges occasioned by his own traffic or that of others by reshaping and compacting with rollers of the size and type necessary for such repair. He shall limit the improved sub-grade preparation to an area easily maintained with the equipment available. Sub-grade preparation and placement of succeeding layer to follow each other closely. The improved sub-grade, when prepared too soon in relation to the placing of the layer above it, is liable to deteriorate, and in such case the Contractor shall, without additional payment, repair, reroll, or re-compact the improved sub-grade as may be necessary to restore it to the state specified herein.

21.9.3.7 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 improved sub-grade level have been checked and approved by the Engineer.

21.9.3.8 Tolerance

The allowable tolerances for the finished improved, sub-grade surface prior to placing the overlying sub-base, base or asphaltic concrete course are given, in the, relevant, "Table for Allowable Tolerances" in these specifications.

21.10 BITUMEN STABILIZED SUBGRADE

21.10.1 DESCRIPTION

The work shall consist of performing all operations in connection with, construction of bitumen stabilized sub-grade and all incidentals in accordance with the specifications in conformity with the lines, grade, thickness and typical cross-sections shown on the plans or as directed by the Engineer.

21.10.2 MATERIAL REQUIREMENTS

21.10.2.1 Soil

This method will only apply to sites with naturally occurring non plastic material such as sand, if the material is brought at site, it shall be non- plastic having uniform gradation,

21.10.2.2 Bitumen

Bituminous material used for sub-grade stabilization shall comply with the requirement as per relevant tables specified in 21.1.18 "Asphaltic Materials" for hot mix asphaltic concrete or can be viscous cut back that requires heating in areas where moisture content of sand is high, necessitating heating and drying of sand.

In dry areas, where natural moisture content of sand is low, the bituminous binder shall be fluid cut back conforming the requirements as given 21.1.18 "Asphaltic Materials".

Bitumen emulsion or foamed penetration grade bitumen can also be used subject to the approval of Engineer after trial test.

Bitumen-sand mixture for the grade of bitumen selected shall be ascertained by trial mixes using Marshall Test to determine the quantity of bitumen required using either heated or unheated sand. The quantity of bitumen required will generally lie between three (3) to six (6) percent by weight of dry sand, the higher proportions being required with fine-grained materials.

21.10.3 CONSTRUCTION REQUIREMENTS

Equipments, tools, and machines used for bitumen stabilized sub-grade shall be subject to the approval of Engineer and shall be maintained in satisfactory working conditions all the times. Mix in place method of bitumen stabilization will be subject to the approval of Engineer to ensure full control of bitumen content, uniform and thorough mixing and satisfactory processing of the material to the full depth of the layer, For scarification of in situ material and spreading of Bituminous material, grader with blade and bitumen distributor shall be used.

The stabilized soil shall be left un-compacted after pulverization and mixing to allow for evaporation of volatile materials thus increasing stability and decreasing water absorption particularly in fine grained sand when temperature is low.

21.10.3.1 Compaction

Immediately after completion of spreading, aeration and shaping operation, the mixture shall be thoroughly compacted with 'rubber or pneumatic tyred rollers. Compaction shall continue until entire width and depth of sub-grade is uniformly compacted to give soaked (96 hours) unconfined compressive strength according to design requirement to meet traffic loading. Steel wheeled tandem roller shall be used to carry out final rolling of compacted surface to eliminate the tyre marks.

To determine the efficiency of mixing, spreading, degree of compaction of equipment and suitability of construction method, trial sections as directed by the Engineer, shall be prepared by the contractor before main work of stabilization is started.

If thickness of compacted layer is less than 20 centimetres, it shall be laid as single operation where as if thickness of compacted stabilized layer is more than twenty centimetre,' material shall be placed in two or more layers, each within the range of eight (8) to twenty (20), centimetres in compacted thickness.

The results of CBR test for measuring the strength of bitumen stabilized materials or cone stability test for designing bitumen-sand mixture shall not supersede those of Marshall Test unless agreed by the Engineer. In-situ density of compacted layer shall be determined using method as described by AASHTO - T-191, AASHTO - T-205 or AASHTO - T-238 and shall be minimum ninety five (95) % modified AASHTO according to the above mentioned methods.

Frequency of testing in field and in laboratory will be according to relevant schedule for sampling and testing of these specifications.

21.10.3.2 Tolerance

Compacted layer shall comply with the tolerance requirements as specified in relevant, "Table for Allowable Tolerances" in these specification.

21.10.3.3 Weather Limitation

The laying of bituminous courses shall be avoided as far as practicable during wet weather and shall be suspended when free standing water is present on the surface. The stabilized material shall not be laid' on any surface, which is frozen or covered with ice or snow and laying shall cease when the air' temperature reaches five (5) degree C on a falling thermometer. Laying shall not commence until the air temperature is at least .five (5) degree C on a rising thermometer unless otherwise directed by the Engineer and also if wet weather threatens to be prolonged the manufacture and laying of stabilized mix shall be suspended.

21.11 DRESSING AND COMPACTION OF BERMS

21.11.1 DESCRIPTION

This work shall consist of scarification of berms, which are undulated or out of level. The existing material shall be scarified, watered, mixed and properly levelled and compacted according to specification described here under or as directed by the Engineer .

21.11.2 MATERIAL REQUIREMENTS

In this item no fresh material is required, however, if fresh material is used it shall be measured and paid under other relative items of works.

21.11.3 CONSTRUCTION REQUIREMENTS

21.11.3.1 Dressing of berm without the use of extra material

In case the berms show undulation of more than 5 cms in level from the reconstructed pavement structure, the berms shall be scarified to a depth of 15 cm and material will be watered, mixed and compact with appropriate equipment approved by-the Engineer.

21.11.3.2 Dressing of berm with the use of extra material

In case the difference of elevation of existing berm with respect to reconstructed road structure is less than 15 cm than additional material (to be measured under other items of work) shall be added to bring the level of berms in conformity with the lines and grades of the existing road. Existing and fresh material shall be properly mixed, watered and compacted as directed by the Engineer.

21.11.3.3 Compaction requirement

Compaction requirement of the fresh and existing material shall be in accordance with the type of material used in berms, as under:

Depth in cms	Compaction requirement as per AASHTO'T-180 (D)
0- 15 (Top layer)	95% for common earth material
0 - 15 (Top layer)	100% for sub-base material

21.11.3.4 Compaction of slopes

While reinstating/dressing of berms, it shall be ensured that compaction requirements are observed on slopes of the berms. The degree of compaction shall be as per direction of the Engineer.

21.12 PAVEMENT WIDENING

21.12.1 DESCRIPTION

This work shall consist of the widening of the existing pavement and finishing of the completed work in accordance with the specifications and in conformity with the lines, grades, thickness of each pavement component and typical cross-sections shown on the plans or as directed by the Engineer.

21.12.2 MATERIALS

Materials for the construction of "Pavement Widening" shall conform to the requirements specified in relevant items of Sub-base .and Base course in these specifications.

21.12.3 TRENCHING

The contractor shall excavate along the edge of the existing pavement for the full depth and width as indicated on the Drawings or as directed by the Engineer. The bottom of the trench shall be compacted with rollers and/or tampers approved by the Engineer to minimum ninety five (95) % of the maximum dry density as per AASHTO T-191 method. If the plans do not call for a specific type of compaction, the sub-grade, sub-base or base shall be compacted by rolling with an approved

type trench roller until the entire surface is smooth, firm and at the designated elevation. Adequate provisions shall be made for drainage of the trench to prevent damage to the sub-grade. Prior to placing any widening material, the trench shall be cleaned of all loose material. The edge of the existing pavement shall be thoroughly cleaned. The trench must be approved by the Engineer, before placing any widening material. All subsequent layers shall be compacted to the degree as shown under relevant item of these specifications

21.12.4 SPECIAL PROVISIONS FOR HANDLING TRAFFIC

Widening operations shall be permitted on only one (1) side of the pavement at a time and excavation of trenches shall be permitted only sufficiently in advance of other operations to ensure a continuity of the operations of excavating, placing widening material, and rolling.

Re-flectorized barricades shall be placed along open trenches day and night. Lighting shall be placed at each barricade at night. Barricades and lights shall be approved by the Engineer. The barricades shall be placed at intervals not to exceed one hundred (100) meters or as directed by the Engineer. The Contractor shall make adequate provision to enable traffic to cross open trenches at intersecting roads; streets and private entrances.

21.13 SCARIFICATION OF EXISTING ROAD / BREAKING OF ROAD PAVEMENT STRUCTURE

21.13.1 DESCRIPTION

This item shall consist of scarification of existing road surface or breaking of existing road pavement structure to ensure bondage of new layer with the existing road pavement and to ensure drainage of water below the surface of freshly laid aggregate base. The surface on which the base material is to be constructed shall be approved and accepted by the Engineer prior to placing the crushed stone base aggregate.

21.13.2 CONSTRUCTION REQUIREMENTS

The method of scarification of road surface or breaking of pavement structure shall be proposed by the contractor and approved by the Engineer in accordance with the requirements under site conditions.

After the existing pavement structure has been broken off, the material shall be removed and disposed off outside the right of way, according to the satisfaction of the Engineer. The surface obtained after scarification or breaking the existing pavement shall be compacted to the density prescribed under 21.1.8.3.

21.9 MEASUREMENT AND PAYMENT

21.9.1 COMPOSITE RATE

The measurement and payment for the items of the work of Road and Road Structures hereof shall be made corresponding to the applicable CSR item as provided in Contract Agreement and shall constitute full compensation, for procurements, transportations, performance in all respect and completion of work as specified including the site clearance as approved by the Engineer-in-Charge.

21.9.2 LABOUR RATE

The measurement and payment for the items of the work of Road and Road Structures hereof shall be made corresponding to applicable CSR item as provided in Contract Agreement and shall constitute full compensation for procurements transportations, performance in all respect and completion of work as specified including site clearance, as approved by the Engineer-in-Charge except the cost of materials to be provided by Department at designated location as defined in the Contract Agreement.

21.9.3 QUANTIFACTION

The unit of measurement shall be measured as mentioned below in accordance with corresponding CSR items.

1. For Volumetric items, the unit of measurement shall be cubic meter or cubic foot. Following items of CSR are measured in the above mentioned criteria;
Item No.:21-1 to 21-9, 21-13 to 21-18, 21-43 to 21-44, 21-52, 21-70, 21-71, 21-74, 21-77 to 21-78,21-83
2. For surface area items, the quantity of work shall be measured by surface area. The unit of measurement shall be Square meter or Square foot. Following item of CSR are measured according to this criteria;
Item No.:21-10 to 21-12, 21-19to 21-29,21-32 to 21-39,21-62 to 21-69,21-72, 21-73, 21-79 ,21-82, 21-85
3. For linear items, the quantity of work shall be measured linearly along centre line of structure. The unit of measurement shall be running meter or running foot. Following items of CSR are measured according to this criteria;
Item No.: 21-45 to 21-51, 21-58 to 21-61,21-75,21-76,21-80
4. For bulk items, the quantity of work shall be measured in units of weight i.e. Tonne or Tons. Following items of CSR are measured according to this criteria;
Item No.: 21-30, 21-31, 21-41
5. The following items of CSR shall be measured as Each;
Item No.: 21-53 to 21-57, 21-84
6. The following items of CSR shall be measured as Each set of One End;
Item No.: 21-81