

## **SECTION 200 SITE CLEARANCE**

### **200.1 SPECIFICATIONS FOR CLEARING AND GRUBBING**

**200.1.1 Scope** - This work shall consist of cutting, removing and disposing of all materials such as trees, bushes, shrubs, stumps, roots, grass, weeds, top organic soil not exceeding 150 mm in thickness, rubbish etc., which in the opinion of the engineer are unsuitable for incorporation in the works, from the area of road land containing road embankment, drains, cross-drainage structures and such other areas as may be specified on the drawings or by the engineer. It shall include necessary excavation, backfilling of pits resulting from uprooting of trees and stumps to required compaction, handling, salvaging, and disposal of cleared materials. Clearing and grubbing shall be performed in advance of earthwork operations and in accordance with the requirements of these Specifications.

**200.1.2 Preservation of property/amenities** - Roadside trees, shrubs, any other plants, pole, lines, fences, signs, monuments, buildings, pipelines, sewers and all highway facilities within or adjacent to the highway which are not to be disturbed shall be protected from injury or damage. The contractor shall provide and install at his own expense, suitable safeguards approved by the engineer for this purpose.

During clearing and grubbing, the contractor shall take all adequate precautions against soil erosion, water pollution, etc., and where required, undertake additional works to that effect vide clause 300.6. Before start of operations, the contractor shall submit to the engineer for approval, his work plan including the procedure to be followed for disposal of waste materials, etc., and the schedules for carrying out temporary and permanent erosion control works as stipulated in clause 300.6.3.

**200.1.3 Methods, tools and equipment** - Only such methods, tools and equipment as are approved by the engineer and which will not affect the property to be preserved shall be adopted for the Work. If the area has thick vegetation/roots/trees, a crawler or pneumatic tyred dozer of adequate capacity may be used for clearance purposes. The dozer shall have ripper attachments for removal of tree stumps. All trees, stumps, etc., falling within excavation and fill lines shall be cut to such depth below ground level that in no case these fall within 500 mm of the subgrade. Also, all vegetation such as roots, under-growth, grass and other deleterious matter unsuitable for incorporation to the satisfaction of the engineer. On areas beyond these limits, trees and stumps required to be removed as directed by the engineer shall be cut down to 1m below ground level so that these do not present an unsightly appearance.

All branches of trees extending above the roadway shall be trimmed as directed by the engineer.

All excavations below the general ground level arising out of the removal of trees, stumps, etc., shall be filled with suitable material and compacted thoroughly so as to make the surface at these points conform to the surrounding area.

Anti-hills both above and below the ground, as are liable to collapse and obstruct free subsoil water flow shall be removed and their workings, which may extend to several metres, shall be suitably treated.

**200.1.4 Disposal of materials** - All materials arising from clearing and grubbing operations shall be the property of government and shall be disposed of by the contractor as hereinafter provided or directed by the engineer.

Trunks, branches and stumps of trees shall be cleaned of limbs and roots and stacked. Also boulders, stones and other materials usable in road construction shall be neatly stacked as directed by the engineer. Stacking of stumps, boulders, stones, etc., shall be done as specified spots with all lifts and upto a lead of 1000m.

All products of clearing and grubbing which, in the opinion of the engineer, cannot be used or auctioned shall be cleared away from the roadside in a manner as directed by the engineer. Cash shall be taken to see that unsuitable waste materials are disposed of in such a manner that there is no likelihood of these getting mixed up with the materials meant for embankment, subgrade and road construction.

**200.1.5 Measurements of payment** - Clearing and grubbing for road embankment, drains and cross-drainage structures shall be measured on area basis in terms of hectares. Clearing and grubbing of borrow areas shall be deemed to be a part of works preparatory of embankment construction and shall be deemed to have been included in the rates quoted for the embankment construction item and no separate payment shall be made for the same. Cutting of trees upto 300 mm in girth including removal of stumps and roots after obtaining prior clearance from the forest department/authorities and trimming of branches of trees extending above the roadway shall be considered incidental to the clearing and grubbing operations. Removal of stumps left over after trees have been cut by any other agency shall also be considered incidental to the clearing and grubbing operations.

Cutting, including removal of stumps and roots if trees of girth above 300 mm and backfilling to required compaction shall be measured in terms of number according to the sizes given below :-

- (i) Above 300 mm to 600 mm
- (ii) Above 600 mm to 900 mm
- (iii) Above 900 mm to 1800 mm
- (iv) Above 1800 mm

For this purpose, the girth shall be measured at a height of 1 metre above ground or at the top of the stump if the height of the stump is less than one metre from the ground.

#### **200.1.6 Rates**

200.1.6.1. The contract unit rates for the various items of clearing and grubbing shall be payment in full for carrying out the required operations including full compensation for all labour, materials, tools, equipment and incidentals necessary to complete the work. These will also include removal of stumps of trees less than 300 mm in girth as well as stumps left over after cutting of trees carried out by another agency, excavation and back-filling to required density, where necessary, and handling, salvaging, piling and disposing of the cleared materials with all lifts and upto a lead of 1000 m.

200.1.6.2. The contract unit rate for cutting (including removal of stumps and roots) of trees of girth above 300 mm shall include excavation and backfilling to required compaction, handling, salvaging, piling and disposing of the cleared materials with all lifts and upto a lead of 1000 m.

200.1.6.3. Where a contract does not include separate items of clearing and grubbing, the same shall be considered incidental to the earthwork items and the contract unit prices for the same shall be considered as including clearing and grubbing operations.

### **200.2 SPECIFICATIONS FOR DISMANTLING CULVERTS, BRIDGES AND OTHER STRUCTURES/PAVEMENTS**

#### **200.2.1 Scope**

This work shall consist of removing, as hereinafter set forth, existing culverts, bridges, pavements, kerbs and other structures like guard-rails, fences, utility services, manholes, catch basins, inlets, etc., which are in place but interfere with the new construction or are not suitable to remain in place recording of pre-measurements and check measurement by competent officers and of salvaging and disposing of the resulting materials and back filling and resulting trenches and pits.

Existing culverts, bridges, pavements and other structures which are within the highway and which are designated for removal, shall be removed upto the limits and extent specified in the drawings or as indicated by the engineer.

Dismantling and removal operations shall be carried out with such equipment and in such a manner as to leave undisturbed, adjacent pavement, structures and any other work to be left in place.

All operations necessary for the removal of any existing structure, which might endanger new construction, shall be completed prior to the start of new work.

**200.2.2 Dismantling culverts and bridges** - The structures shall be dismantled carefully and the resulting materials so removed as not to cause any damage to the serviceable materials to be salvaged, the part of the structure to be retained and any other properties or structures nearby.

Unless otherwise specified, the superstructure portion of culverts/bridges shall be entirely removed and other parts removed below the ground level or as necessary depending upon the interference they cause to the new construction. Removal of overlaying or adjacent material, if required in connection with the dismantling of the structures, shall be incidental to this item.

Where existing culverts/bridges are to be extended or otherwise incorporated in the new work, only such part or parts of the existing structure shall be removed as are necessary and directed by the engineer to provide a proper connection to the new work. The connecting edges shall be cut, chipped and trimmed to the required lines and grades without weakening or damaging any part of the structure to be retained. Due care should be taken to ensure that reinforcing bars which are to be left in place so as to project into a new work as dowels or ties are not injured during removal of concrete.

Pipe culverts shall be carefully removed in such a manner as to avoid damage to the pipes.

Steel structures shall, unless otherwise provided, be carefully dismantled in such a manner as to avoid damage to members thereof. If specified in the drawings or directed by the engineer that the structure is to be removed in a condition suitable for re-erection, all members shall be match-marked by the contractor with white lead paint before dismantling; end pins, nuts, loose plates, etc., shall be similarly marked to indicate their proper location; all pins, pin holes and machined surfaces shall be painted with a mixture of white lead and tallow and all loose parts shall be securely wired to adjacent members or packed in boxes.

Timber structures shall be removed in such a manner as to avoid damage to such timber or lumber as is designated by the engineer to be salvaged.

**200.2.3 Dismantling pavements and other structures** - In removing pavements, kerbs, gutters, and other structures like guard-rails, fences, manholes, catch basins, inlets, etc., where portions of the existing construction are to be left in the finished work, the same shall be removed to an existing joint or cut and chipped to a true line with a face perpendicular to the surface of the existing structure. Sufficient removal shall be made to provide for proper grades and connections with the new work as directed by the engineer.

All concrete pavements, base courses in carriageway and shoulders etc., designated for removal shall be broken to pieces whose volume shall not exceed 0.02 cum. and stockpiled locations if the material is to be used later or otherwise arranged for disposal as directed (see clause 200.2.5).

**200.2.4 Back-filling** - Holes and depressions caused by dismantling operations shall be backfilled with excavated or other approved materials and compacted to required density as directed by the engineer.

**200.2.5 Disposal of materials** - All materials obtained by dismantling shall be the property of government. Unless otherwise specified, materials having any salvage value shall be placed in neat stacks of like materials within the right-of-way, as directed by the engineer with all lifts and upto a lead of 1000 m.

Pipe culverts that are removed shall be cleaned and neatly piled on the right-of-way at points designated by the engineer with all lifts and lead upto 1000 m.

Structural steel removed from old structures shall, unless otherwise specified or directed, be stored in a neat and presentable manner on blocks in location suitable for loading. Structures or portions thereof which are specified in the contract for re-erection shall be stored in separate piles.

Timber or lumber from old structures which is designated by the engineer as materials to be salvaged shall have all nails and bolts removed therefrom and shall be stored in neat piles in locations suitable for loading.

All materials obtained from dismantling operations which, in the opinion of the engineer, cannot be used or auctioned shall be disposed off as directed by the engineer with all lifts and upto a lead of 1000 m.

**200.2.6 Measurements for payment** - The work of dismantling structures shall be paid for in units indicated below by taking measurements before and after, as applicable.

(i) Dismantling brick/stone masonry/ concrete (plain and reinforced)	cu.m
(ii) Dismantling flexible and cement concrete pavement	cu.m
(iii) Dismantling steel structures	tonne
(iv) Dismantling timber structures	cu.m
(v) Dismantling pipes, guard rails, kerbs, gutters and fencing	linear m
(vi) Utility services	Nos.

**200.3 Rates** - The contract unit rates for the various items of dismantling shall be paid in full for carrying out the required operations including full compensation for all labour, materials, tools, equipment, safeguards and incidentals necessary to complete the work. These will also include excavation and backfilling where necessary to the required compaction and for handling, salvaging, piling and disposing of the dismantled materials within all lifts and upto a lead of 1000 m.

## **SECTION 300**

### **EARTH WORK, EROSION CONTROL AND DRAINAGE**

#### **300.1 SPECIFICATIONS FOR EXCAVATION FOR ROADWAYS AND DRAINS**

**300.1.1 Scope** - This work shall consist of excavation, removal and satisfactory disposal of all materials necessary for the construction of roadway, side drains and waterways in accordance with requirements of these specifications and the lines, grades and cross-sections shown in the drawings or as indicated by the engineer. It shall include the hauling and stacking of or hauling to sites of embankment and subgrade construction, suitable cut materials as required, as also the disposal of unsuitable cut materials in specified manner, trimming and finishing of the road to specified dimensions or as directed by the engineer.

#### **300.1.2 Classification of excavated material**

**300.1.2.1 Classification** - All materials involved in excavation shall be classified by the engineer in the following manner:

**a) Soil** - This shall comprise topsoil, turf, sand, silt, loam, clay, mud, peat, black cotton soil, soft shale or loose moorum, a mixture of these and similar material, which yields to the ordinary application of pick, spade, and/or shovel, rake or other ordinary digging implement. Removal of gravel or any other nodular material having dimension in any one direction not exceeding 75 mm occurring in such strata shall be deemed to be covered under this category.

**(b) Ordinary rock (not requiring blasting) This shall include:**

**(i) rock types such as laterites, shales and conglomerates, varieties of limestone and sand stone etc., , which may be quarried or split with crow bars, also including any rock, which in dry state may be hard, requiring blasting but, which, when wet, becomes soft and manageable by means other than blasting;**

(ii) macadam surfaces such as water bound and bitumen/tar bound; soling of roads; paths etc. and hard core; compact moorum or stabilised soil requiring grafting tool or pick or both and shovel, closely applied; gravel and cobble stone having maximum dimension in any one direction between 75 and 300 mm;

(iii) lime concrete, stone masonry in lime mortar and brick work in lime/cement mortar below ground level, reinforced cement concrete, which may be broken up with crow bars or picks and sand stone masonry in cement mortar below ground level; and

(iv) boulders, which do not require blasting having maximum dimension in any direction of more than 300 mm, found lying loose on the surface or embedded in river bed, soil, talus, slope wash and terrace material of dissimilar origin.

**(c ) Hard rock (requiring blasting)** - This shall comprise :

(i) any rock or cement concrete for the excavation of , which the use of mechanical plant and/or blasting is required;

(ii) reinforced cement concrete (reinforcement cut through but not separated from the concrete) below ground level; and

(iii) boulders requiring blasting.

**(d) Hard rock (blasting prohibited)** - Hard rock requiring blasting as described under (c) but where blasting is prohibited for any reason and excavation has to be carried out by chiselling, wedging or any other agreed method.

**(e) Marshy Soil** - This shall include soils like soft clays and peats excavated below the original ground level of marshes and swamps and soils excavated from other areas requiring continuous pumping or bailing out of water.

**300.1.2.2. Authority for classification** - The classification of excavation shall be decided by the engineer and his decision shall be final and binding on the contractor. Merely the use of explosives in excavation will not be considered, as a reason for higher classification unless blasting is clearly necessary in the opinion of the engineer.

### **300.1.3 Construction operations**

**300.1.3.1 Setting out** - After the site has been cleared as per clause 201, the limits of excavation shall be set out true to lines, curves, slopes, grades and sections as shown on the drawings or as directed by the engineer. The contractor shall provide all labour, survey instruments and materials such as strings, pegs, nails, bamboos, stones, lime, mortar, concrete, etc., required in connection with the setting out of works and the establishment of bench marks. The contractor shall be responsible for the maintenance of bench, marks and other marks and stakes as long as in the opinion of the engineer, they are required for the work.

**300.1.3.2 Stripping and storing topsoil** - When so directed by the engineer, the topsoil existing over the sites of excavation shall be stripped to specified depths constituting Horizon "A" and stockpiled at designated locations for re-use in covering embankment slopes, cut slopes, berms and other disturbed areas where re-vegetation is desired. Prior to stripping the topsoil, all trees, shrubs, etc., shall be removed along with roots, with approval of the engineer.

**300.1.3.3 Excavation – General** - All excavations shall be carried out in conformity with the directions laid here in under and in a manner approved by the engineer. The work shall be so done that the suitable materials available from excavation are satisfactorily utilized as decided upon beforehand.

300.11 While planning or executing excavations, the contractor shall take all adequate precautions against soil erosion, water pollution etc. as per clause 300.6, and take appropriate drainage measures to keep the site free of water in accordance with clause 300.11. The excavation shall conform to the lines, grades, side slopes and levels shown on the drawings or as directed by the engineer. The contractor shall not excavate outside the limits of excavation. Subject to the permitted tolerances, any excess depth/width excavated beyond the specified levels/dimensions on the drawings shall be made good at the cost of the contractor with suitable material of characteristics similar to that removed and compacted to the requirements of clause 300.5

All debris and loose material on the slopes of cuttings shall be removed. No backfilling shall be allowed to obtain slopes excepting that when boulders or soft materials are encountered in cut slopes, these shall be excavated to approved depth on instructions of the engineer and the resulting cavities filled with suitable material and thoroughly compacted in an approved manner.

After excavation, the sides of excavated area shall be trimmed and the area contoured to minimise erosion and ponding, allowing for natural drainage to take place. If trees were removed, new trees shall be planted, as directed by the engineer. The cost of planting new trees shall be deemed to be incidental to the work.

**300.1.3.4 Methods, tools and equipment** - Only such methods, tools and equipment as approved by the engineer shall be adopted/used in the work. If so desired by the engineer, the contractor shall demonstrate the efficacy of the type of equipment to be used before the commencement of work.

**300.1.3.5 Rock excavation** - Rock, when encountered in road excavation, shall be removed upto the formation level or as otherwise indicated on the drawings. Where, however, unstable shales or other unsuitable materials are encountered at the formation level, these shall be excavated to the extent of 500 mm below the formation level or as otherwise specified. In all cases, the excavation operations shall be so carried out that at no point uncut formation of the rock protrudes above the specified levels. Rocks and large boulders, which are likely to cause differential settlement and also local drainage problems should be removed to the extent of 500 mm below the formation level in full formation width including drains and cut through the side drains.



Where excavation is done to levels lower than those specified, the excess excavation shall be made good as per clauses 300.1.3.3. and 300.1.6 to the satisfaction of the engineer. Slopes in rock cutting shall be finished to uniform lines corresponding to slope lines shown on the drawings or as directed by the engineer. Notwithstanding the foregoing, all loose pieces of rock on excavated slope surface, which move when pierced by a crowbar shall be removed.

Where blasting is to be resorted to, the same shall be carried out as per clause 300.2 and all precautions indicated therein observed.

Where presplitting is prescribed to be done for the establishment of a specified slope in rock excavation, the same shall be carried out in clause 300.3.

**300.1.3.6 Marsh excavation** - The excavation of soils from marshes/swamps shall be carried out as per the programme approved by the engineer.

Excavation of marshes shall begin at one end and proceed in one direction across the entire marsh immediately ahead of backfilling. The method and sequence of excavating and backfilling shall be such as to ensure, to the extent practicable, the complete removal or displacement of all muck from within the lateral limits called for on the drawings or as staked by the engineer, and to the bottom of the marsh, firm support or levels indicated.

**300.1.3.7 Excavation of road shoulders/verge/median for widening of pavement or providing treated shoulders** - In works involving widening of existing pavements or providing treated shoulders, unless otherwise specified, the shoulder/verge/median shall be removed to their full width and to levels shown on drawings or as indicated by the engineer. While doing so, care shall be taken to see that no portion of the existing pavement designated for retention is loosened or disturbed. If the existing pavement gets disturbed or loosened, it shall be dismantled and cut to a regular shape with sides vertical and the disturbed/loosened portion removed completely and relaid as directed by the engineer, at the cost of the contractor.

**300.1.3.8 Excavation for surface/sub-surface drains** - Where the contract provides for construction of surface/sub-surface drains as in clause 300.9, excavation for these shall be carried out in proper sequence with other works as approved by the engineer.

**300.1.3.9 Slides** - If slips, slides, over-breaks or subsidence occur in cuttings during the process of construction, they shall be removed at the cost of the contractor as ordered by the engineer. Adequate precautions shall be taken to ensure that during construction, the slopes are not rendered unstable or give rise to recurrent slides after construction.

If finished slopes slide into the roadway subsequently, such slides shall be removed and paid for at the contract rate for the class of excavation involved, provided the slides are not due to any negligence on the part of the contractor. The classification of the debris material from the slips, slides etc. shall conform to its condition at the time of removal and payment made accordingly regardless of its condition earlier.

**300.1.3.10 Dewatering** - If water is met with in the excavations due to springs, seepage, rain or other causes, it shall be removed by suitable diversions, pumping or bailing out and the excavation kept dry whenever so required or directed by the engineer. Care shall be taken to discharge the drained water into suitable outlets as not to cause damage to the works crops or any other property. Due to any negligence on the part of the contractor, if any such damage is caused, it shall be the sole responsibility of the contractor to repair/restore to the original condition at his own cost or compensate for the damage.

**300.1.3.11 Disposal of excavated materials** - All the excavated materials shall be the property of the employer. The material obtained from the excavation of roadway, shoulders, verges, drains, cross-drainage works etc., shall be used for filling up of (i) roadway embankment, (ii) the existing pits in the right-of-way and (iii) for landscaping of the road as directed by the engineer, including levelling and spreading with all lifts and lead upto 1000 m and no extra payment shall be made for the same. All hard materials, such as hard moorum, rubble, etc., not intended for use as above shall be stacked neatly on specified land as directed by the engineer with all lifts and lead upto 1000 m.

Unsuitable and surplus material not intended for use within the lead specified above shall also, if necessary, be transported with all lifts and lead beyond initial 1000 m, disposed of or used as directed by the engineer.

**300.1.3.12 Backfilling** - Backfilling of masonry/concrete/hume pipe drain excavation shall be done with approved material after concrete/masonry/hume pipe is fully set and carried out in such a way as not to cause undue thrust on any part of the structure and/or not to cause differential settlement. All space between the drain walls and the side of the excavation shall be refilled to the original surface making due allowance for settlement, in layers generally not exceeding 150 mm compacted thickness to the required density, using suitable compaction equipment such as mechanical tamper, rammer or plate compactor as directed by the engineer.

**300.1.4 Plying of construction traffic** - Construction traffic shall not use the cut formation and finished subgrade without prior permission of the engineer. Any damage arising out of such use shall be made good by the contractor at his own expense.

**300.1.5 Preservation of property** - The contractor shall undertake all reasonable precautions for the protection and preservation of any or all existing roadside trees, drains, sewers or other sub-surface drains, pipes, conduits and any other structures under or above ground, , which may be affected by construction operations and , which, in the opinion of the engineer, shall be continued in use without any change. Safety measures taken by the contractor in this respect shall be got approved from the engineer. However, if any of these objects is damaged by reason of the contractor's negligence, it shall be replaced or restored to the original condition at his expense. If the contractor fails to do so, within the required time as directed by the engineer or if, in the opinion of the engineer, the actions initiated by the contractor to replace/restore the damaged objects are not satisfactory, the engineer shall arrange the replacement/restoration directly through any other agency at the risk and cost of the contractor after issuing a prior notice to the effect.

**300.1.6 Preparation of cut formation** - The cut formation, , which serves as a subgrade, shall be prepared to receive the sub-base/base course as directed by the engineer.

Where the material in the subgrade (that is within 500 mm from the lowest level of the pavement) has a density less than specified in Table 300-2, the same shall be loosened to a depth of 500 mm and compacted in layers in accordance with the requirements of clause 305. Any unsuitable material encountered in the subgrade level shall be removed as directed by the engineer and replaced with suitable material compacted in accordance with clause 305.

In rocky formations, the surface irregularities shall be corrected and the levels brought up to the specified elevation with granular base material as directed by the engineer, laid and compacted in accordance with the respective specifications for these materials. The unsuitable material shall be disposed of in accordance with clause 300.1.3.11. After satisfying the density requirements, the cut formation shall be prepared to receive the subbase/base course in accordance with clause 300.10 and 300.11 to receive the sub-base/base course.

**300.1.7 Finishing operations** - Finishing operations shall include the work of properly shaping and dressing all excavated surfaces.

When completed, no point on the slopes shall vary from the designated slopes by more than 150 mm measured at right angles to the slope, except where excavation is in rock (hard or soft) where no point shall vary more than 300 mm from the designated slope. In no case shall any portion of the slope encroach on the roadway.

The finished cut formation shall satisfy the surface tolerances described in clause 900.2. Where directed, the topsoil removed earlier and conserved (clauses 300.1.3.2 and 300.5.3.3) shall be spread over cut slopes, where feasible, berms and other disturbed areas. Slopes may be roughened and moistened slightly, prior to the application of topsoil, in order to provide satisfactory bond. The depth of topsoil shall be sufficient to sustain plant growth, the usual thickness being from 75 mm to 100 mm.

**300.1.8 Measurements for payment** - Excavation for roadway shall be measured by taking cross-sections at suitable intervals in the original position before the work starts and after its completion and computing the volumes in cu. m. by the method of average end areas for each class of material encountered. Where it is not feasible to compute volumes by this method because of erratic location of isolated deposits, the volumes shall be computed by other accepted methods.

At the option of the engineer, the contractor shall leave depth indicator during excavations of such shape and size and in such positions as directed so as to indicate the original ground level as accurately as possible. The contractor shall see that these remain intact till the final measurements are taken.

For rock excavation, the overburden shall be removed first so that necessary cross-section could be taken for measurement. Where cross-sectional measurements could not be taken due to irregular configuration or where the rock is admixed with other classes of materials, the volumes shall be computed on the basis of stacks of excavated rubble after making 35 per cent deduction therefrom. When volumes are calculated in this manner for excavated material other than rock, deduction made will be to the extent of 16 per cent of stacked volumes.

Works involved in the preparation of cut formation shall be measured in units indicated below:

- (i) Loosening and recompacting the  
loosened material at subgrade..... cu. m.
- (ii) Loosening and removal of unsuitable  
material and replacing with a suitable  
material and compacting to  
required density..... cu. m.
- (iii) Preparing rocky subgrade .....sq. m.

- (iv) Stripping including storing and reapplication of topsoil.....cu. m.
- (v) Disposal of surplus material beyond .....cu. m.  
initial 1000 m lead

### **300.1.9 Rates**

300.1.9.1 The contract unit rates for the items of roadway and drain excavation shall be payment in full for carrying out the operations required for the individual items including full compensation for :

- (i) setting out;
- (ii) transporting the excavated materials and depositing the same on sites of embankments, spoil banks or stacking as directed within all lifts and lead upto 1000 m or as otherwise specified;
- (iii) trimming bottoms and slopes of excavation ;
- (iv) dewatering;
- (v) keeping the work free of water as per clause 300.11 ; and
- (vi) all labour, materials, tools, equipment, safety measures, testing and incidentals necessary to complete the work to specifications.

Provided, however, where presplitting is prescribed to achieve a specified slope in rock excavation, the same shall be paid for vide clause 300.3.5.

300.1.9.2 The contract unit rate for loosening and recompacting the loosened materials at subgrade shall include full compensation for loosening to the specified depth, including breaking clods, spreading in layers, watering where necessary and compacting to the requirements.

300.1.9.2 clauses 300.1.9.1 and 300.5.8 shall apply as regards contract unit rate for item of removal of unsuitable material and replacement with suitable material respectively.

300.1.9.3 The contract unit rate for item of preparing rocky subgrade as per clause 300.1.6 shall be full compensation for providing, laying and compacting granular base material for correcting surface irregularities including all materials, labour and incidentals necessary to complete the work and all leads and lifts.

300.1.9.4 The contract unit rate for the items of stripping and storing topsoil and of reapplication of topsoil shall include full compensation for all the necessary operations including all lifts, but leads upto 1000 m.

300.1.9.5 The contract unit rate for disposal of surplus earth from roadway and drain excavation shall be full compensation for all labour, equipment, tools and incidentals necessary on account of the additional haul or transportation involved beyond the initial lead of 1000 m.

#### **300.4 Specification for excavation for structures**

**300.4.1 Scope** - Excavation for structures shall consist of the removal of material for the construction of foundations for bridges, culverts, retaining walls, headwalls, cutoff walls, pipe culverts and other similar structures, in accordance with the requirements of these Specifications and the lines and dimensions shown on the drawings or as indicated by the engineer. The work shall include construction of the necessary cofferdams and cribs and their subsequent removal; all necessary sheeting, shoring, bracing, draining and pumping; the removal of all logs, stumps, grubs and other deleterious matter and obstructions, necessary for placing and foundations; trimming bottoms of excavations; backfilling and clearing up the site and the disposal of all surplus material.

**300.4.2 Classification of excavation** - All materials involved in excavation shall be classified in accordance with clause 300.1.2.

#### **300.4.3 Construction operations**

**300.4.3.1. Setting out** - After the site has been cleared according to clause 200.1, all limits of excavation shall be set out true to lines, curves and slopes to clause 300.1.3.1.

**300.4.3.2. Excavation** - Excavation shall be taken to the width of the lowest step of the footing and the sides shall be left plumb where the nature of soil allows it. Where the nature of soil or the depth of the trench and season of the year do not permit vertical sides, the contractor shall put up necessary shoring, strutting and planking or cut slopes to a safer angle or both with due regard to the safety of personnel and works and to the satisfaction of the engineer.

The depth to , which the excavation is to be carried out shall be as shown on the drawings, unless the type of material encountered is such as to require changes, in , which case the depth shall be as ordered by the engineer. Propping shall be undertaken when any foundation or stressed zone from an adjoining structure is within a line of 1 vertical to 2 horizontal from the bottom of the excavation.

Where blasting is to be resorted to, the same shall be carried out in accordance with clause 300.2 and all precautions indicated therein observed. Where blasting is likely to endanger adjoining foundations or other structures, necessary precautions such as controlled blasting, providing rubber mat cover to prevent flying of debris etc. shall be taken to prevent any damage.

**300.4.3.3.Dewatering and protection** - Normally, open foundations shall be laid dry. Where water is met with in excavation due to stream flow, seepage, springs, rain or other reasons, the contractor shall take adequate measures such as bailing, pumping, constructing diversion channels, drainage channels, bunds, depression of water level by well-point system, cofferdams and other necessary works to keep the foundation trenches dry when so required and to protect the green concrete/masonry against damage by erosion or sudden rising of water level. The methods to be adopted in this regard and other details thereof shall be left to the choice of the contractor but subject to approval of the engineer. Approval of the engineer shall, however, not relieve the contractor of the responsibility for the adequacy of dewatering and protection arrangements and for the quality and safety of the works.

Where cofferdams are required, these shall be carried out adequate depths and heights, be safely designed and constructed and be made as watertight as is necessary for facilitating construction to be carried out inside them. The interior dimensions of the cofferdams shall be such as to give sufficient clearance for the construction and inspection and to permit installation of pumping equipments, etc., inside the enclosed area.

If it is determined before hand that the foundations cannot be laid dry or the situation is found that the percolation is too heavy for keeping the foundation dry, the foundation concrete shall be laid under water by tremie pipe only. In case of flowing water or artesian springs, the flow shall be stopped or reduced as far as possible at the time of placing the concrete.

Pumping from the interior of any foundation enclosure shall be done in such a manner as to preclude the possibility of the movement of water through any fresh concrete. No pumping shall be permitted during the placing of concrete or for any period of at least 24 hours thereafter, unless it is done from a suitable sump separated from the concrete work by a watertight wall or other similar means.

At the discretion of the contractor, cement grouting or other approved methods may be used to prevent or reduce seepage and to protect the excavation area. The contractor shall take all precautions in diverting channels and in discharging the drained water as not to cause damage to the works, crops or any other property.

**300.4.3.4 Preparation of foundation** - The bottom of the foundation shall be levelled both longitudinally and transversely or stepped as directed by the engineer. Before footing is laid, the surface shall be slightly watered and rammed. In the event of excavation having been made deeper than that shown on the drawings or as otherwise ordered by the engineer, the extra depth shall be made up with concrete or masonry of the foundation at the cost of the contractor as per clause 2100.4.1 Ordinary filling shall not be used for the purpose to bring the foundation to level.

When rock or other hard strata is encountered, it shall be freed of all soft and loose material, cleaned and to cut to a firm surface either level and stepped as directed by the engineer. All seams shall be cleaned out and filled with cement mortar or grout to the satisfaction of the engineer. In the case of the excavation in rock, annular space around footing shall be filled with lean concrete (1:3:6 nominal mix) upto the top level of rock.

When foundation piles are used, the excavation of each pit shall be substantially completed before beginning pile-driving operations therein. After pile-driving operations in a given pit are completed, all loose and displaced materials therein shall be removed to the elevation of the bottom of the footings.

**300.4.3.5. Slips and slip-outs** - If there are any slips or slip-outs in the excavation, these shall be removed by the contractor at his own cost.

**300.4.3.6 Public safety** - Near towns, villages and all frequented places, trenches and foundation pits shall be securely fenced, provided with proper caution signs and marked with red lights at night to avoid accidents. The contractor shall take adequate protective measures to see that the excavation operations do not affect or damage adjoining structures. For safety precautions, guidance may be taken from IS: 3764, copy enclosed vide Annexure 300-A.1

**300.4.3.7 Backfilling** - Backfilling shall be done with approved material after concrete or masonry is fully set and carried out in such a way as not to cause undue thrust on any part of the structure. All space between foundation masonry or concrete and the sides of excavation shall be refilled to the original surface in layers not exceeding 150 mm compacted thickness. The compaction shall be done with the help of suitable equipment such as mechanical tamper, rammer, plate vibrator etc., after necessary watering, so as to achieve a density not less than the field density before excavation.

**300.4.3.8 Disposal of surplus excavated materials** - Clause 300.1.3.11., shall supply.

**300.4.4. Measurements for payment** - Excavation for structure shall be measured in cu. m., for each class of material encountered, limited to the dimensions shown on the drawings or as directed by the engineer. Excavation over increased width, cutting of slopes, shoring, shuttering and planking shall be deemed as convenience for the contractor in executing the work and shall not be measured and paid for separately, unless specifically provided for in the contract documents.

Preparation of rock foundation shall be measured in square metres. Foundation sealing, dewatering, including pumping shall be deemed to be incidental to the work unless separate provision is made for in the contract. In the latter case, payment shall be on lumpsum basis as provided in the bill of quantities.



### **300.4.5 Rates**

300.4.5.1 The contract unit rate for the items of excavations for structures shall be payment in full for carrying out the required operations including full compensation for :

- (i) setting out ;
- (ii) construction of necessary cofferdams, cribs, sheeting, shoring and bracing and their subsequent removal;
- (iii) removal of all logs, stumps, grubs and other deleterious matter and obstructions, for placing the foundations including trimming of bottoms of excavations;
- (iv) foundation sealing, dewatering including pumping when no separate provision for it is made in the contract;
- (v) backfilling, clearing up the site and disposal of all surplus material within all lifts and leads upto 1000 m or as otherwise specified; and
- (vi) all labour, materials, tools, equipment, safety measures, diversion of traffic and incidentals necessary to complete the work to specifications.

300.4.5.2. The contract unit rate for preparation of rock foundation shall be full compensation for cutting, trimming and cleaning the foundation surface and filling/sealing of all seams with cement grout or mortar including all materials, labour and incidentals required for completing the work.

300.4.5.3 The contract unit rate for transporting materials from the excavation for structures shall be full compensation for all labour, equipment, tools and incidentals necessary on account of the additional haul or transportation involved beyond the initial lead of 1000 m.

### **300.5 SPECIFICATIONS FOR EMBANKMENT CONSTRUCTION**

**300.5.1 General description** - These Specifications shall apply to the construction of embankments including subgrades, earthen shoulders and miscellaneous backfills with approved material obtained from roadway and drain excavation, borrow pits or other sources. All embankments, subgrades, earthen shoulders and miscellaneous backfills shall be constructed in accordance with the requirements of these Specifications and in conformity with lines, grades, and cross-sections shown on the drawings or as directed by the engineer.

### **300.5 Materials and general requirements**

#### **300.5.2.1 Physical requirements**

300.5.2.1.1 The materials used in embankments, subgrades, earthen shoulders and miscellaneous backfills shall be soil, moorum, gravel, a mixture of these or any other

material approved by the engineer. Such materials shall be free of logs, stumps, roots, rubbish or any other ingredient likely to deteriorate or affect the stability of the embankment/subgrade.

The following types of material shall be considered unsuitable for embankment:

1. Materials from swamps, marshes and bogs;
2. Peat, log, stump and perishable material; any soil that classifies at OL, OI, OH or Pt in accordance with IS; 1498, copy enclosed vide Annexure 300-A.2.
3. Materials susceptible to spontaneous combustion;
4. Materials in a frozen condition;
5. Clay having liquid limit exceeding 70 and plasticity index exceeding 45; and
6. Materials with salts resulting in leaching in the embankment.

300.5.2.1.2 Expansive clay exhibiting marked swell and shrinkage properties ("free swelling index" exceeding 50 per cent when tested as per IS : 2720-Part 40 shall not be used as a fill material, subgrade and top 500 mm portion of the embankment just below subgrade shall be non-expansive in nature.

300.5.2.1.3 Any fill material with a soluble sulphate content exceeding 1.9%, grams of sulphate (expressed as  $\text{SO}_3$ ) per litre when tested in accordance with BS; 1377 Test 10 but using a 2:1 water-soil ratio shall not be deposited within 500 mm or other distance described in the contract, of concrete, cement bound materials or other cementitious materials forming part of the permanent works.

Materials with a total sulphate content (expressed as  $\text{SO}_3$ ) exceeding 0.5 per cent by mass, when tested in accordance with BS: 1377 Test 9 shall not be deposited within 500 mm, or other distances described in the contract, of metallic items forming part of the permanent works.

300.5.2.1.4 The size of the coarse material in the mixture of earth shall ordinarily not exceed 75 mm when being placed in the embankment and 50 mm when placed in the subgrade. However, the engineer may at his discretion permit the use of material coarser than this also if he is satisfied that the same will not present any difficulty as regards the placement of fill material and its compaction to the requirements of these specifications. The maximum particle size shall not be more than two-thirds of the compacted layer thickness.

300.5.2.1.5 Ordinarily, only the materials satisfying the density requirements given in Table 300-1 shall be employed for the construction of the embankment and subgrade.

Table 300-1 Density requirements of embankment and subgrade materials

Sl.No	Type of work	Maximum laboratory dry unit weight when tested as per IS:2720 (part 8)
1	Embankments up to 3 metres Height, not subjected to extensive Flooding.	Not less than 15.2. K N/Cu.m
2	Embankments exceeding 3 metres Height or embankments of any height Subject to long periods of inundation	Not less than 16.0 kN/cu.m.
3	Subgrade and earthen shoulders/ Verges/backfill	Not less than 17.5.kN/cu.m.

Notes : (1) This table is not applicable for lightweight fill material e.g. cinder, fly ash etc.

(2) The engineer may relax these requirements at his discretion taking into account the availability of materials for construction and other relevant factors.

(3) The material to be used in subgrade should also satisfy design CBR at the dry unit weight applicable as per Table 300-2.

**300.5.2.2 General requirements** - The materials for embankment shall be obtained from approved sources with preference given to materials becoming available from nearby roadway excavation or any other excavation under the same contract.

The work shall be so planned and executed that the best available materials are saved for the subgrade and the embankment portion just below the subgrade.

**300.5.2.2.2. Borrow materials** - Where the materials are to be obtained from designated borrow areas, the location, size and shape of these areas shall be as indicated by the engineer and the same shall not be opened without his written permission. Where specific borrow areas are not designated by the employer/the engineer, arrangement for locating the source of supply of material for embankment and subgrade as well as compliance to environmental requirements in respect of excavation and borrow areas as stipulated, from time to time by the Ministry of Environment and Forests, Government of India and the local bodies, as applicable, shall be sole responsibility of the contractor.

Haulage of material to embankments or other areas of fill shall proceed only when sufficient spreading and compaction plant is operating at the place of deposition.

No excavated acceptable material other than surplus to requirements of the contract shall be removed from the site. Should the contractor be permitted to remove acceptable material from the site to suit his operational procedure, then he shall make good any consequent deficit of material arising therefrom.

Where the excavation reveals a combination of acceptable and unacceptable materials, the

contractor shall, unless otherwise agreed by the engineer, carry out the excavation in such a manner that the acceptable materials are excavated separately for use in the permanent works without contamination by the unacceptable materials. The acceptable materials shall be stockpiled separately.

The contractor shall ensure that he does not adversely affect the design dimension so that surplus material may be trimmed, ensuring that the remaining material is to be density and in position specified and conforms to the specified side slopes.

The contractor shall obtain representative samples from each of the identified borrow areas and have these tested at the site laboratory following a testing programme approved by the engineer. It shall be ensured that the subgrade material when compacted to the density requirements as in Table 300-2 shall yield the design CBR value of the subgrade.

**300.5.2.2.4 Dewatering** - If the foundation of the embankment is in an area with stagnant water, and in the opinion of the engineer it is feasible to remove it, the same shall be removed by bailing out or pumping, as directed by the engineer and the area of the embankment foundation shall be kept dry. Care shall be taken to discharge the drained water so as not to cause damage to the works, crops or any other property. Due to any negligence on the part of the contractor, if any such damage is caused, it shall be the sole responsibility of the contractor to repair/restore it to original condition or compensate the damage at his own cost.

If the embankment is to be constructed under water, clause 300.5.4.6. shall apply.

**300.5.2.2.4 Stripping and storing topsoil** - In localities where most of the available embankment materials are not conducive to plant growth, or when so directed by the engineer, the topsoil from all areas of cutting and from all areas to be covered by embankment foundation shall be stripped to specified depths not exceeding 150 mm and stored in stockpiles of height not exceeding 2 m for covering embankment slopes, cut slopes and other disturbed areas where re-vegetation is desired. Topsoil shall not be unnecessarily trafficked either before stripping or when in a stockpile. Stockpiles shall not be surcharged or otherwise loaded and multiple handling shall be kept to a minimum.

**300.5.2.2.5. Compacting ground supporting embankment/subgrade** - Where necessary, the original ground shall be levelled to facilitate placement of first layer of embankment, scarified, mixed with water and then compacted by rolling so as to achieve minimum dry density as given in Table 300-2.

In case where the difference between the subgrade level (top of the subgrade on, which pavement rests) and ground level is less than 0.5 m and the ground does not have 97 percent relative compaction with respect to the dry density as given in Table 300-2, the ground shall be loosened upto a level 0.5 m below the subgrade level, watered and

compacted in layers in accordance with clauses 300.5.3.5 and 300.5.3.6 to not less than 97 per cent of dry density as given in Table 300-2.

Where so directed by the engineer, any unsuitable material occurring in the embankment foundation shall be removed and replaced by approved materials laid in layers to the required degree of compaction.

Table 300-2 Compaction requirements for embankment and subgrade

Sl.No	Type of work / material	Relative compaction as percentage of max. laboratory dry density as per IS : 2720 (Part 8)
1	Subgrade and earthen shoulders	Not less than 97
2	Embankment	Not less than 95
3	Expansive Clays (a) Subgrade and 500 mm portion just below the subgrade (b) Remaining portion of Embankment	Not allowed  Not less than 90

The contractor shall at least 7 working days before commencement of compaction submit the following to the engineer for approval:

- 1) The values of maximum dry density and optimum moisture content obtained in accordance with IS : 2720 (part 7) or (part 8), as the case may be, appropriate for each of the fill materials he intends to use.
- 2) A graph of density plotted against moisture content from, which each of the values in (1) above of maximum dry density and optimum moisture content were determined.
- 3) The Dry density – moisture content – CBR relationships for light, intermediate and heavy compactive efforts (light corresponding to IS: 2720 (Part 7), heavy corresponding to IS 2720 (Part 8) and intermediate in-between the two) for each of the fill materials he intends to use in the subgrade.

Once the above information has been approved by the engineer, it shall form the basis for compaction.

### **300.5.3 Construction operations**

**300.5.3.1. Setting out:** After the site has been cleared to clause 200.1, the work shall be set out to clause 300.1.3.1. The limits of embankment/subgrade shall be marked by fixing batter pegs on both sides at regular intervals as guides before commencing the earthwork. The embankment/subgrade shall be built sufficiently wider than the design dimension so that surplus material may be trimmed ensuring that the desired material is to the required density and in position specified and confirms to the specified side slopes.

**Embankment or subgrade work shall not proceed until the foundations for embankment/subgrade have been inspected by the engineer for satisfactory condition and approved.**

300.5.3.4. Any foundation treatment specified for embankments especially high embankments, resting on suspect foundations as revealed by borehole logs shall be carried out in a manner and to the depth as desired by the engineer. Where the ground on which an embankment is to be built has any of the material types (a) to (f) clause 300.5.2.1, at least 500 mm of such material must be removed and replaced by acceptable fill material before embankment construction commences.

#### **300.5.3.5. Spreading material in layers and bringing to appropriate moisture content.**

300.5.3.5.1 The embankment and subgrade material shall be spread in layers of uniform thickness not exceeding 200 mm compacted thickness over the entire width of embankment by mechanical means, finished by a motor grader and compacted as per clause 305.3.6. The motor grader blade shall have hydraulic control suitable for initial adjustment and maintain the same so as to achieve the specific slope and grade. Successive layers shall not be placed until the layer under construction has been thoroughly compacted to the specified requirements as in Table 300-2 and got approved by the engineer. Each compacted layer shall be finished parallel to the final cross-section of the embankment.

300.5.3.5.2 Moisture content of the material shall be checked at the site of placement prior to commencement of compaction; if found to be out of aged limits, the same shall be made good. Where water is required to be added in such constructions, water shall be sprinkled from a water tanker fitted with sprinkler capable of applying water uniformly with a controllable rate of flow to a variable widths of surface but without any flooding. The water shall be added uniformly thoroughly mixed in soil by blading, discing or harrowing until a uniform moisture content is obtained throughout the depth of the layer. If the material delivered to the roadbed is too wet, it shall be dried, by aeration and exposure to the sun, till the moisture content is acceptable for compaction. Should circumstances arise, where owing to wet weather, the moisture content cannot be reduced to the required amount by the above procedure, compaction work shall be suspended.

Moisture content of each layer of soil shall be checked in accordance with IS: 2720 (Part 2)- and unless otherwise mentioned, shall be so adjusted, making due allowance for evaporation losses, that at the time of compaction it is in the range of 1 per cent above to 2 per cent below the optimum moisture content determined in accordance with IS : 2720 (Part

7) or IS : 2720 (Part 8) as the case may be. Expansive clays shall, however, be compacted at moisture content corresponding to the specified dry density, but on the wet side of the optimum moisture content obtained from the laboratory compaction curve.

After adding the required amount of water, the soil shall be processed by means of grader, harrows, rotary mixers or as otherwise approved by the engineer until the layer is uniformly wet.

Clods or hard lumps or earth shall be broken to have a maximum size of 75 mm when being placed in the embankment and a maximum size of 50 mm when being placed in the subgrade.

300.5.3.5.3. Embankment and other areas of fill shall, unless otherwise required in the contract or permitted by the engineer, be constructed evenly over their full width and their fullest possible extent and the contractor shall control and direct construction plant and other vehicular traffic uniformly over them. Damage by construction plant and other vehicular traffic shall be made good by the contractor with material having the same characteristics and strength as the material had before it was damaged.

Embankments and other areas of unsupported fills shall not be constructed with steeper side slopes, or to greater widths than those shown in the contract, except to permit adequate compaction at the edges before trimming back, or to obtain the final profile following any settlement of the fill and the underlying material.

Whenever fill is to be deposited against the face of a natural slope, or sloping earthworks face including embankments, cuttings, other fills and excavations steeper than 1 vertical on 4 horizontal, such faces shall be benched as per clause 300.5.4.1 immediately before placing the subsequent fill.

All permanent faces of side slopes of embankments and other areas of fill formed shall, subsequent to any trimming operations, be reworked and sealed to the satisfaction of the engineer by tracking a tracked vehicle, considered suitable by the engineer, on the slope or any other method approved by the engineer.

**300.5.3.6. Compaction** - Only the compaction equipment approved by the engineer shall be employed to compact the different material types encountered during construction. Smooth wheeled, vibratory, pneumatic tired, sheepsfoot or pad foot rollers, etc. of suitable size and capacity as approved by the engineer shall be used for the different types and grades of materials required to be compacted either individually or in suitable combinations.

The compaction shall be done with the help of vibratory roller of 80 to 100 kN static weight with plain or pad foot drum or heavy pneumatic tired roller of adequate capacity capable of achieving required compaction.

The contractor shall demonstrate the efficacy of the equipment he intends to use by carrying

out compaction trials. The procedure to be adopted for these site trials shall first be submitted to the engineer for approval.

Earthmoving plant shall not be accepted as compaction equipment nor shall the use of a lighter category of plant to provide any preliminary compaction to assist the use of heavier plant be taken into account.

Each layer of the material shall be thoroughly compacted to the densities specified in Table 300-2. Subsequent layers shall be placed only after the finished layer has been tested according to clause 900.3.2.2 and accepted by the engineer. The engineer may permit measurement of field dry density by a nuclear moisture/density gauge used in accordance with agreed procedure and the gauge is calibrated to provide results identical to that obtained from tests in accordance with IS : 2720 (Part 28)-copy enclosed as Annexure 300-A.7. A record of the same shall be maintained by the contractor.

When density measurements reveal any soft areas in the embankment /subgrade / earthen shoulders, further compaction shall be carried out as directed by the engineer. If in spite of that the specified compaction is not achieved, the material in the soft areas shall be removed and replaced by approved material, compacted to the density requirements and satisfaction of the engineer.

**3005.5.3.7. Drainage** - The surface of the embankment/subgrade at all times during construction shall be maintained at such a cross fall (not flatter than that required for effective drainage of an earthen surface) as will shed water and prevent ponding.

**300.5.3.8 Repairing of damages caused by rain/spillage of water** - The soil in the affected portion shall be removed in such areas as directed by the engineer before next layer is laid and refilled in layers and compacted using appropriate mechanical means such as small vibratory roller, plate compactor or power rammer to achieve the required density in accordance with clause 300.5.3.6. If the cut is not sufficiently wide for use of required mechanical means for compaction, the same shall be widened suitably to permit their use for proper compaction. Tests shall be carried out as directed by the engineer to ascertain the density requirements of the repaired area. The work of repairing the damages including widening of the cut, if any, shall be carried out by the contractor at his own cost, including the arranging of machinery / equipment for the purpose.

**300.5.3.9. Finishing operations** - Finishing operations shall include the work of shading and dressing the shoulders/verge/roadbed and side slopes to conform to the alignment, levels, cross-sections and dimensions shown on the drawings or as directed by the engineer subject to the surface tolerance described in clause 900.2. Both the upper and lower ends of the side slopes shall be rounded off to improve appearance and to merge the embankment with the adjacent terrain.



The topsoil, removed and conserved earlier (clause 300.1.3.2 and 300.5.3.3) shall be spread over the fill slopes as per directions of the engineer to facilitate the growth of vegetation. Slopes shall be roughened and moistened slightly prior to the application of the topsoil in order to provide satisfactory bond. The depth of the topsoil shall be sufficient to sustain plant growth, the usual thickness being from 75 mm to 150 mm.

Where directed, the slopes shall be turfed with sods in accordance with clause 300.7. If seeding and mulching of slopes is prescribed, this shall be done to the requirement of clause 300.8.

When earthwork operations have been substantially completed, the road area shall be cleared of all debris, and ugly scars in the construction area responsible for objectionable appearance eliminated.

#### **300.5.4 ADDITIONAL SPECIFICATIONS CONSTRUCTION OF EMBANKMENT AND SUBGRADE UNDER SPECIAL CONDITIONS**

**300.5.4.1. Earthwork for widening existing road embankment** - When an existing embankment and/or subgrade is to be widened and its slopes are steeper than 1 vertical on 4 horizontal, continuous horizontal benches, each at least 300 mm wide, shall be cut into the old slope for ensuring adequate bond with the fresh embankment/subgrade material to be added. The material obtained from cutting of benches could be utilized in the widening of the embankment/subgrade. However, when the existing slope against which the fresh material is to be placed is flatter than 1 vertical on 4 horizontal, the slope surface may only be ploughed or scarified instead of resorting to benching.

Where the width of the widened portions is insufficient to permit the use of conventional rollers, compaction shall be carried out with the help of small vibratory rollers/plane compactors/power rammers or any other appropriate equipment approved by the engineer. End dumping of material from trucks for widening operations shall be avoided except in difficult circumstances when the extra width is too narrow to permit the movement of any other types of hauling equipment.

**300.5.2.2 Earthwork for embankment and subgrade to be placed against sloping ground:** where an embankment / subgrade is to be placed against sloping ground, the latter shall be appropriately benched or ploughed/scarified as required in clause 300.5.4.1., before placing the embankment/subgrade material. Extra earthwork involved in benching or due to ploughing / scarifying etc. shall be considered incidental to the work.

For wet conditions, benches with slightly inward fall and subsoil drains at the lowest point shall be provided as per the drawings, before the fill is placed against sloping ground.

Where the contract requires construction of transverse subsurface drain at the cut – fill interface, work on the same shall be carried out to clause 300.9 in proper sequence with the embankment and subgrade work as approved by the engineer.

**300.5.4.3 Earthwork over existing road surface:** Where the embankment is to be placed over an existing road surface, the work shall be carried out as indicated below:-

1) If the existing road surface is of granular or bituminous type and lies within 1 m of the new subgrade level, the same shall be scarified to a depth of 50 mm or more if specified, so as to provide ample bond between the old and new material ensuring that at least 500 mm portion below the top of new subgrade level is compacted to the desired density.

2) If the existing road surface is of cement concrete type and lies within 1 m of the new subgrade level the same shall be removed completely.

3) If the level difference between the existing road surface and the new formation level is more than 1 m, the existing surface shall be permitted to stay in place without any modification.

**300.5.4.4 Embankment and subgrade around structures** - To avoid interference with the construction of abutments, wing walls or return walls of culvert/bridge structures, the contractor shall, at points to be determined by the engineer suspend work on embankment forming approaches to such structures, until such time as the construction of the latter is sufficiently advanced to permit the completion of approaches without the risk of damage to the structure.

Unless directed otherwise, the filling around culverts, bridges and other structures upto a distance of twice the height of the road from the back of the abutment shall be carried out independent of the work on the main embankment. The fill material shall not be placed against any abutment or wing wall, unless permission has been given by the engineer but in any case not until the concrete or masonry has been in position for 14 days. The embankment and subgrade shall be brought up simultaneously in equal layers on each side of the structure to avoid displacement and unequal pressure. The sequence of work in this regard shall be got approved from the engineer.

The material used backfill shall not be an organic soil or highly plastic clay having plasticity index and liquid limit more than 20 and 40 respectively when tested according to IS: 2720 (Part 5) - Filling behind abutments and wing walls for all structures shall conform to the general guidelines given in Appendix 6 of IRC: 78 (Standard Specifications and Code of Practice of Road Bridges-Section VII) - in respect of the type of material, the extent of backfill, its laying and compaction etc. The fill material shall be deposited in horizontal layers in loose thickness and compacted thoroughly to the requirements of Table 300-2.

Where the provision of any filter medium is specified behind the abutment, the same shall be laid in layers simultaneously with the laying of fill material. The material used for filter shall conform to the requirements for filter medium spelt out in clause 2500.2/300.9.3.2., (B) unless otherwise specified in the contract.

Where it may be impracticable to use conventional rollers, the compaction shall be carried out by appropriate mechanical means such as small vibratory roller, plate compactor or power rammer. Care shall be taken to see that the compaction equipment does not hit or come too close to any structural member so as to cause any damage to them or excessive pressure against the structure.

**300.5.4.5 ADDITIONAL SPECIFICATIONS CONSTRUCTION OF EMBANKMENT OVER GROUND INCAPABLE OF SUPPORTING CONSTRUCTION EQUIPMENT** - Where

embankment is to be constructed across ground, which will not support the weight of repeated heavy loads of construction equipment, the first layer of the fill may be constructed by placing successive loads of material in a uniformly distributed layer of a minimum thickness required to support the construction equipment as permitted by the engineer. The contractor, if so desired by him, may also use suitable geo-synthetic material to increase the bearing capacity of the foundation. This exception to normal procedure will not be permitted where, in the opinion of the engineer, the embankments could be constructed in the approved manner over such ground by the use of lighter or modified equipment after proper ditching and drainage have been provided. Where this exception is permitted, the selection of the material and the construction procedure to obtain an acceptable layer shall be the responsibility of the contractor. The cost of providing suitable traffic conditions for construction equipment over any area of the contract will be the responsibility of the contractor and no extra payment will be made to him. The remainder of the embankment shall be constructed as specified in clause 300.5.3.

**300.5.4.6 ADDITIONAL SPECIFICATIONS FOREMBANKMENT CONSTRUCTION UNDER WATER** - Where filling or backfilling is to be placed under water, only acceptable

granular material or rock shall be used unless otherwise approved by the engineer. Acceptable granular material shall consist of graded, hard durable particles with maximum particle size not exceeding 75 mm. The material should be non-plastic having uniformity coefficient of not less than 10. The material placed in open water shall be deposited by end tipping without compaction.

**300.5.4.7 ADDITIONAL SPECIFICATIONS EARTHWORK FOR HIGH EMBANKMENT** - In the case of high embankments, the contractor shall normally use the material from the specified borrow area. In case he desires to use different material for his own convenience, he shall have to carry out necessary soil investigations and redesign the high embankment at his own cost. The contractor shall then furnish the soil test data and design of high embankment for approval of the engineer, who reserves the right to accept or reject it.

If necessary, stage construction of fills and any controlled rates of filling shall be carried out in accordance with the contract including installation of instruments and its monitoring.

Where required, the contractor shall surcharge embankments or other areas of fill with approved material for the periods specified in the contract. If settlement of surcharged fill results in any surcharging material, , which is unacceptable for use in the fill being surcharged, lying below formation level, the contractor shall remove the unacceptable material and dispose it as per direction of the engineer. He shall then bring the resultant level up to formation level with acceptable material.

**300.5.4.8 Settlement period** - Where settlement period is specified in the contract, the embankment shall remain in place for the required settlement period before excavating for abutment, wingwall, retaining wall, footings, etc., or driving foundation piles. The duration of the required settlement period at each location shall be as provided for in the contract or as directed by the engineer.

**300.5.5 Plying of traffic** - Construction and other vehicular traffic shall not use the prepared surface of the embankment and/or subgrade without the prior permission of the engineer. Any damage arising out of such use shall, however, be made good by the contractor at his own expense as directed by the engineer.

**300.5.6 Surface finish and quality control of work** - The surface finish of construction of subgrade shall conform to the requirements of clause 900.2. Control on the quality of materials and works shall be exercised in accordance with clause 900.3.

#### **300.5.7 Subgrade strength**

300.5.7.1 It shall be ensured prior to actual execution that the borrow area material to be used in the subgrade satisfies the requirements of design CBR.

300.5.7.2 Subgrade shall be compacted and finished to the design strength consistent with other physical requirements. The actual laboratory CBR values of constructed subgrade shall be determined on undisturbed samples cut from the compacted subgrade in CBR mould fitted with cutting shoe or on remoulded samples, compacted to the field density at the fixed moisture content.

**300.5.8 Measurements for payment** - Earth embankment/subgrade construction shall be measured separately by taking cross sections at intervals in the original position before the work starts and after its completion and computing the volumes of earthwork in cubic metres by the method of average end areas. The measurements of fill material from borrow areas shall be the difference between the net quantities of compacted fill and the net quantities of suitable material sought from roadway and drainage excavation. For this purpose, it shall be assumed that one cu. m. of suitable material brought to site from road and drainage

excavation forms one cu. m. of compacted fill and all bulking or shrinkage shall be ignored.

Construction of embankment under water shall be measured in cu. m.

Construction of high embankment with specified material and in specified manner shall be measured in cu. m.

Stripping including storing and reapplication of topsoil shall be measured in cu. m.

Work involving loosening and recompacting of ground supporting embankment/subgrade shall be measured in cu. m.

Removal of unsuitable material at embankment /subgrade foundation and replacement with suitable material shall be measured in cu. m.

Scarifying existing granular/bituminous road surface shall be measured in square metres.

Dismantling and removal of existing cement concrete pavement shall be measured vide clause 200.2.6.

Filter medium and backfill material behind abutments, wing walls and other retaining structures shall be measured as finished work in position in cu. m.

### **300.5.9 Rates**

300.5.9.1 The contract unit rates for the items of embankment and subgrade construction shall be payment in full for carrying out the required operations including full compensation for :

1) Cost of arrangement of land as a source of supply of material of required quantity for construction unless provided otherwise in the contract ;

2) Setting out ;

1) Compacting ground supporting embankment/subgrade except where removal and replacement of unsuitable material or loosening and recompacting is involved;

2) Scarifying or cutting continuous horizontal benches 300 mm wide on side slopes of existing embankment and subgrade as applicable ;

5) Cost of watering or drying of material in borrow areas and/or embankment and subgrade during construction as required;

6) Spreading in layers, bringing to appropriate moisture content and compacting to Specifications requirements ;

7) Shaping and dressing top and slopes of the embankment and subgrade including rounding of corners;

8) Restricted working at sites of structure ;

9) Working on narrow width of embankment and subgrade;

10) Excavation in all soils from borrow pits/designated borrow areas including clearing and grubbing and transporting the material to embankment and subgrade site with all lifts and leads unless otherwise provided for in the contract;

11) All labour, materials, tools, equipment and incidentals necessary to complete the work to the Specifications;

12) Dewatering; and

13) Keeping the embankment/ completed formation free of water as per clause 300.11.

300.5.9.2. In case the contract unit rate specified is not inclusive of all leads, the unit rate for transporting material beyond the initial lead, as specified in the contract for construction of embankment and subgrade shall be inclusive of full compensation for all labour, equipment, tools and incidentals necessary on account of the additional haul or transportation involved beyond the specified initial lead.

300.5.9.3. Clause 300.1.9.5 shall apply as regards contract unit rates for items of stripping and storing topsoil and of reapplication of topsoil.

300.5.9.4., clause 300.1.9.2., shall apply as regards contract unit rate for the item of loosening and recompacting the embankment/subgrade foundation.

300.5.9.5. clauses 300.1.9.1., and 300.5.8 shall apply as regards contract rates for items of removal of unsuitable material and replacement with suitable material respectively.

300.5.9.6. The contract unit rate for scarifying existing granular/bituminous road surface shall be payment in full for carrying out the required operations including full compensation for all labour, materials, tools, equipment and incidentals necessary to complete the work. This will comprise of handling, salvaging, stacking and disposing of the dismantled materials within all lifts and upto a lead of 1000 m or as otherwise specified.

300.5.9.7. Clause 200.2.7 shall apply as regards contract unit rate for dismantling and removal of existing cement concrete pavement.

300.5.9.8. The contract unit rate for providing and laying filter material behind abutments shall be payment in full for carrying out the required operations including all materials,

labour, tools, equipment and incidentals to complete the work to specifications.

300.5.9.9. Clause 300.5.4.6 shall apply as regards contract unit rate for construction of embankment under water.

300.5.9.10 Clause 300.5.4.7 shall apply as regards contract unit rate for construction of high embankment. It shall include cost of instrumentation, its monitoring and settlement period, where specified in the contract or directed by the engineer.

## **SECTION 400**

### **GRANULAR SUB-BASE, BASES(NON-BITUMINOUS) AND SHOULDERS**

#### **400.1 SPECIFICATIONS FOR GRANULAR SUB-BASE, BASES(NON-BITUMINOUS) AND SHOULDERS**

**400.1.1 Scope** - This work shall consist of laying and compacting well-graded material on prepared subgrade in accordance with the requirements of these specifications. The material shall be laid one or more layers as sub-base or lower sub-base and upper sub-base (termed as sub-base hereinafter) as necessary according to lines, grades and cross-sections shown on the drawings or as directed by the engineer.

##### **400.1.2 Materials**

400.1.2.1 The material to be used for the work shall be natural sand, moorum, gravel, crushed stone, or combination thereof depending upon the grading required. Materials like crushed slag, crushed concrete, brick metal and kankar may be allowed only with the specific approval of the engineer. The material shall be free from organic or other deleterious constituents and conform to one of the three gradings given in Table 400-1.

While the gradings in Table 400-1 are in respect of close-graded granular sub-base materials, one each for maximum particle size of 75 mm, 53 mm and 26.5 mm, the corresponding gradings for the coarse-graded materials for each of the three maximum particle sizes are given at Table 400-2. The grading to be adopted for a project shall be as specified in the contract.

**400.1.2.2 Physical requirements** - The material shall have a 10 per cent fines value of 50 KN or more (for sample in soaked condition) when tested in compliance with BIS:812 (Part III). The water absorption value of the coarse aggregate shall be determined as per IS : 2386 (Part 3) if this value is greater than 2 per cent, the soundness test shall be carried out on the material delivered to site as per IS : 383 For Grading II and III materials, the CBR shall be determined at the density and moisture content likely to be developed at the density and moisture content likely to be developed in equilibrium conditions which shall be taken as being the density relating to a uniform air voids content of 5 per cent.

Table 400-1 Grading for close graded granular sub-base materials

IS sieve	Percent by weight passing the IS sieve		
Designation	Grading I	Grading II	Grading III
75.0 mm	100	-	-
53.0 mm	80-100	100	-
26.5 mm	55-90	70-100	100
9.50 mm	35-65	50-80	65-95
4.75 mm	25-55	40-65	50-80
2.36 mm	20-40	30-50	40-65
0.425 mm	10-25	15-25	20-35
0.075 mm	3-10	3-10	3-10
CBR value (Minimum)	30	25	20

Table 40-0-2 Grading for coarse graded granular sub-base materials

IS sieve	Percent by weight passing the IS sieve		
Designation	Grading I	Grading II	Grading III
75.0 mm	100	-	-
53.0 mm		100	
26.5 mm	55-75	50-80	100
9.50 mm			
4.75 mm	10-30	15-35	25-45
2.36 mm			
0.425 mm			
0.075 mm	<10	<10	<10
CBR value (minimum)	30	25	20

Note: The material passing 425 micron (0,425 mm) sieve for all the three gradings when tested according to IS : 2720 (Part 5) shall have liquid limit and plasticity index not more than 25 and 6 per cent respectively.

**400.1.3 Strength of sub-base** - It shall be ensured prior to actual execution that the material to be used in the sub-base satisfies the requirements of CBR and other physical requirements when compacted and finished.

When directed by the engineer, this shall be verified by performing CBR tests in laboratory as required on specimens remoulded at field dry density and moisture content and any other tests for the "quality" of materials, as may be necessary.

#### **400.1.4 Construction operations**

**400.1.4.1 Preparation of subgrade** - Immediately prior to the laying of sub-base, the subgrade already finished to clause 300.1 to 300.5 as applicable shall be prepared by



removing all vegetation and other extraneous matter, lightly sprinkled with water if necessary and rolled with two passes of 80 – 100 KN smooth wheeled roller.

**400.1.4.2 Spreading and compacting** - The sub-base material of grading specified in the contract shall be spread on the prepared subgrade with the help of a mortar grader of adequate capacity, its blade having hydraulic controls suitable for initial adjustment and for maintaining the required slope and grade during the operation or other means as approved by the engineer.

When the sub-base material consists of combination of materials mentioned in clause 400.1.2.1, mixing shall be done mechanically by the mix-in-place method.

Manual mixing shall be permitted only where the width of laying is not adequate for mechanical operations, as in small-sized jobs. The equipment used for mix-in-place construction shall be a rotavator or similar approved equipment capable of mixing the material to the desired degree. If so desired by the engineer, trial runs with the equipment shall be carried out to establish its suitability for the work.

Moisture content of the loose material shall be checked in accordance with IS : 2720 (Part 2) and suitably adjusted by sprinkling additional water from a truck mounted or trailer mounted water tank and suitable for applying water uniformly and at controlled quantities to variable widths of surface or other means approved by the engineer so that, at the time of compaction, it is from 1 per cent above to 2 per cent below the optimum moisture content corresponding to IS: 2720 (Part 8). While adding water, due allowance shall be made for evaporation losses. After water has been added, the material shall be processed by mechanical or other approved means like disc harrows, rotavators until the layer is uniformly wet.

Immediately thereafter, rolling shall start, if the thickness of the compacted layer does not exceed 100 mm, a smooth wheeled roller of 80 to 100 KN weight may be used. For a compacted single layer upto 225mm the compaction shall be done with the help of a vibratory roller of minimum 80 to 100 KN static weight with plain drum or pad foot-drum or heavy pneumatic tyred roller of minimum 200 to 300 KN weight having a minimum tyre pressure of 0.7 MN/m<sup>2</sup> or equivalent capacity roller capable of achieving the required compaction. Rolling shall commence at the lower edge and proceed towards the upper edge longitudinally for portions having unidirectional crossfall and super-elevation and shall commence at the edges and progress towards the centre for portions having crossfall on both sides.

*Each pass of the roller shall uniformly overlap not less than one-third of the track made in the preceding pass. During rolling, the grade and crossfall (camber) shall be checked and any high spots or depressions, which becomes apparent, corrected by removing or adding fresh material. The speed of the roller shall not exceed 5 km per hour. Rolling shall be continued till the density achieved is at least 98 per cent of the maximum dry for the material determined as per IS : 2720 (Part 8). The surface of any layer of material on completion of compaction shall be well closed, free from movement under compaction equipment and from compaction planes, ridges, cracks or loose material. All loose, segregated or otherwise defective areas shall be made good to the full thickness of layer and re-compacted.*

**400.1.5 Surface finish and quality control of work** - The surface finish of construction shall conform to the requirements of clause 900.2. Control on the quality of materials and works shall be exercised by the engineer in accordance with section 900.

**400.1.6. Arrangements for traffic** - During the period of construction, arrangement of traffic shall be maintained in accordance with clause 100.12.

**400.1.7. Measurement for payment** - Granular sub-base shall be measured as finished work in position in cubic metres. The protection of edges of granular sub-base extended over the full formation as shown in the drawing shall be considered incidental to the work of providing granular sub-base and as such no extra payment shall be made for the same.

**400.1.8. Rate** - The contract unit rate for granular sub-base shall be payment in for carrying out the required operations including full compensation for:

- (i) making arrangements for traffic according to clause 100.12 except for initial treatment to verges, shoulders and construction of diversions;
- (ii) furnishing all materials to be incorporated in the work including all royalties, fees, rents where necessary and all leads and lifts;
- (iii) all labour, tools, equipment and incidentals to complete the work to the specifications;
- (iv) carrying out the work in part widths of road where directed; and
- (v) carrying out the required tests for quality control.

#### **400.4 SPECIFICATIONS FOR WATER BOUND MACADAM SUB – BASE / BASE**

##### **400.4.1. Scope**

400.4.1.1 This work shall consist of clean, crushed aggregates mechanically interlocked by rolling and bonding together with screening, binding material where necessary and water laid on a properly prepared subgrade/sub-base / base or existing pavement, as the case may be and finished in accordance with the requirements of these specifications and in close conformity with the lines, grades, cross-sections and thickness as per approved plans or as directed by the engineer.

400.4.1.2 It is, however, not desirable to lay water bound macadam on an existing thin black topped surface without providing adequate drainage facility for water that would get accumulated at the interface of existing bituminous surface and water bound macadam.

##### **400.4.2 Materials**

**400.4.2.1. Coarse aggregates** - Coarse aggregates shall be either crushed or broken stone, crushed slag, overburnt (Jhama) brick aggregates or any other naturally occurring aggregates such as kankar and laterite of suitable quality. Materials other than crushed or broken stone and crushed slag shall be used in sub-base courses only. If crushed gravel/shingle is used, not less than 90 per cent by weight of the gravel/shingle pieces retained on 4.75 mm sieve shall have at least two fractured faces. The aggregates shall conform to the

physical requirements set forth in Table 400-6. The type and size range of the aggregate shall be specified in the contract or shall be as specified by the engineer. If the water absorption value of the coarse aggregate is greater than 2 per cent, the soundness test shall be carried out on the material delivered to site as per IS : 2386 (Part 5)- copy enclosed as Annexure.

**400.4.2.2. Crushed or broken stone** - The crushed or broken stone shall be hard, durable and free from excess flat, elongated, soft and distinguished particles, dirt and other deleterious material.

Table 400-6, Physical requirements of coarse aggregates for water bound macadam for sub– base courses

	Test	Test Method	Requirements
1	* Los Angeles Abrasion value Or *Aggregate impact value	IS:2386  IS:2386 (Part-4) or IS:5640**	40 percent (Maxi.)  30 percent (Maxi.)
2	Combined Flakiness and Elongation indices (Total)***	IS:2386 (Part - 1)	30 percent (Maxi.)

\* Aggregate may satisfy requirements of either of the two sets.

\*\* Aggregates like brick metal, kankar, laterite etc. which get softened in presence of water shall be tested for Impact value under wet condition in accordance with IS : 5640.

\*\*\* The requirement of flakiness index and elongation index shall be enforced only in the case of crushed broken stone and crushed slag.

**400.4.2.3. Crushed slag** - Crushed slag shall be made from air-cooled blast furnace slag. It shall be of angular shape, reasonably uniform in quality and density and generally free from thin, elongated and soft pieces, dirt or other deleterious materials. The weight of crushed slag shall not be less than 11.2 KN per m<sup>3</sup> and the percentage of glossy material shall not be more than 20. It should also comply with the following requirements:

(i)	Chemical stability	To comply with requirements of appendix of BS : 1047
(ii)	Sulphur content	Maximum 2 per cent
(iii)	Water absorption	Maximum 10 per cent

**400.4.2.4. Overburnt brick aggregates** - Brick aggregates shall be made from overburnt bricks or brick bats and be free from dust and other objectionable and deleterious materials.

**400.4.2.5. Grading requirement of coarse aggregates** - The coarse aggregates shall conform to one of the Gradings given in Table 400 – 7 as specified, provided, however, the use of Grading No. 1 shall be restricted to sub-base courses only.

Table 400 – 7, Grading requirements of coarse aggregates

Gradation	Size range	I.S. Sieve designation	Percent by weight passing
1	90 mm to 45 mm	125 mm	100
		90 mm	90-100
		63 mm	25-60
		45 mm	0-15
		22.4 mm	0-5
2	63 to 45 mm	90 mm	100
		63 mm	90-100
		53 mm	25-75
		45 mm	0-15
		22.4 mm	0-5
3	53 to 22.4 mm	63 mm	100
		53 mm	95-100
		45 mm	65-90
		22.4 mm	0-10
		11.2 mm	0-5

Note: The compacted thickness for a layer with Grading 1 shall be 100 mm while for layer with other gradings i.e., 2 & 3, it shall be 75 mm.

**400.4.2.6. Screenings** - Screenings to fill voids in the coarse aggregate shall generally consist of the same material as the coarse aggregate. However, where permitted, predominantly non-plastic material such as moorum or gravel (other than rounded river borne material) may be used for this purpose provided liquid limit and plasticity index of such material are below 20 and 6 respectively and fraction passing 75 micron sieve does not exceed 10 per cent.

Screenings shall conform to the grading set forth in Table 400-8. The consolidated details of quantity of screenings required for various grades of stone aggregates are given in Table 400 – 9. The table also gives the quantities of materials (loose) required for 10 m<sup>2</sup> for sub-base base compacted thickness of 100/75 mm. The use of screenings shall be omitted in the case of soft aggregates such as brick metal, kankar, laterites, etc. as they are likely to get crushed to a certain extent under rollers.

Table 400 – 8, Grading for screenings

Grading classification	Size of Screenings	IS Sieve designation	Per cent by weight passing the IS sieve
A	13.2 mm	13.2 mm	100
		11.2 mm	95-100
		5.6 mm	15-35
		180 mcn	0-10
B	11.2 mm	11.2 mm	100
		5.6 mm	90-100
		180 mcn	15-35

Table 400 – 9, Approximate quantities of coarse aggregates and screenings required for  
100 / 75 mm compacted thickness of water bound macadam (wbm) sub-base /  
base course for 10 m<sup>2</sup> area

Classification	Size Range	Compact thickness	Loose Qty.	Screenings			
				Stone screening		Crushable type such as mooram or gravel	
				Grading classification and size	For WBM sub-base/ base course (loose Qty)	Grading classification and size	Loose Qty.
Grading1	90 mm to 45 mm	100 mm	1.21 to 1.43 m <sup>3</sup>	Type A 13.2 mm	0.27 to 0.30 m <sup>3</sup>	Not Uniform	0.30 to 0.32 m <sup>3</sup>
Grading2	63mm to 45 mm	75 mm	0.91 to 1.07m <sup>3</sup>	Type A 13.2 mm	0.12 to 0.15 m <sup>3</sup>	- do -	0.22 to 0.24 m <sup>3</sup>
- do -	- do -	- do -	- do -	Type B 11.2 mm	0.20 to 0.22 m <sup>3</sup>	- do -	- do -
Grading3	53mm to 22.4 mm	75 mm	- do -	- do -	0.18 to 0.21 m <sup>3</sup>	- do -	- do -

**400. 4.2.7. Binding material** - Binding material to be used for water bound macadam as a filter material meant for preventing ravelling, shall comprise of a suitable material approved by the engineer having a Plasticity Index (PI) value of less than 6 as determined in accordance with IS : 2720 (Part 5).

The quantity of binding material where it is to be used, will depend on the type of screenings. Generally, the quantity required for 75 mm compacted thickness of water bound macadam will be 0.06 – 0.09 m<sup>3</sup> / 10m<sup>2</sup> and 0.08 – 0.10 m<sup>3</sup>/ 10 m<sup>2</sup> for 100 mm compacted thickness.

The above mentioned quantities should be taken as a guide only, for estimation of quantities for construction etc.

Application of binding materials may not be necessary when the screenings used are of crushable type such as moorum or gravel.

#### **400.4 Construction operations**

**400.4.3.1 Preparation of base** - The surface of the subgrade /sub-base/base to the specified lines and crossfall (camber) and made free of dust and other extraneous material. Any ruts or soft yielding places shall be corrected in an approved manner and rolled until firm surface is obtained if necessary by sprinkling water. Any sub-base /base / surface irregularities, where predominant, shall be made good by providing appropriate type of profile corrective course (levelling course) to clause 500.1 of these specifications.

As far as possible, laying water bound macadam course over an existing thick bituminous layer may be avoided since it will cause problems of internal drainage of the pavement at the interface of two courses. It is desirable to completely pick out the existing thin bituminous wearing course where water bound macadam is proposed to be laid over it. However, where the intensity of rain is low and the interface drainage facility is efficient, water bound macadam can be laid over the existing thin bituminous surface by cutting 50 mm x 50 mm furrows at an angle of 45 degrees to the centre line of the pavement at one metre intervals in the existing road. The directions and depth of furrows shall be such that they provide adequate bondage and also serve to drain water to the existing granular base course beneath the existing thin bituminous surface.

**400.4 3.2 Inverted choke** - If water bound macadam is to be laid directly over the subgrade, without any other intervening pavement course, a 25 mm course of screenings (Grading B) or coarse sand shall be spread on the prepared subgrade before application of the aggregates is taken up. In case of a fine sand or silty or clayey subgrade, it is advisable to lay 100 mm insulating layer of screening or coarse sand on top of fine grained soil, the gradation of which will depend upon whether it is intended to act as a drainage layer as well. As a preferred alternative to inverted to act as a drainage layer as well. As a preferred alternative to inverted choke, appropriate geosynthetics performing functions of separation and drainage may be used over the prepared subgrade as directed by the engineer. section 700 shall be applicable for use of geosynthetics.

**400.4.3.3 Spreading coarse aggregates** - The coarse aggregates shall be spread uniformly and evenly upon the prepared subgrade/sub-base/base to proper profile by using templates placed across the road about 6 m apart, in such quantities that the thickness of each compacted layer is not more than 100 mm for Grading 1 and 75 mm for Grading 2 and 3, as specified in clause 400.4.2.5. Wherever possible, approved mechanical devices such as aggregates spreader shall be used to spread the aggregates uniformly so as to minimise the need for manual rectification afterwards. Aggregates placed at spread in one or more layers by any approved means so as to achieve the specified results.

The spreading shall be done from stockpiles along the side of the roadway or directly from vehicles. No segregation of large or fine aggregates shall be allowed and the coarse aggregate as spread shall be of uniform gradation with no pockets of fine material.

The surface of the aggregates spread shall be carefully checked with templates and all high or low spots remedied by removing or adding aggregates as may be required. The surface shall be checked frequently with a straight edge while spreading and rolling so as to ensure a finished surface as per approved drawings.

The coarse aggregates shall not normally be spread more than 3 days in advance of the subsequent construction operations.

**400.4.3.4 Rolling** - Immediately following the spreading of the coarse aggregate, rolling shall be started with three wheeled power rollers of 80 to 100 KN capacity or tandem or vibratory rollers of 80 to 100 KN static weight. The type of roller to be used shall be approved by the engineer based on trial run.

Except on superelevated portions where the rolling shall proceed from inner edge to the outer, rolling shall begin from the edges gradually progressing towards the centre. First the edge/ edges shall be compacted with roller running forward and backward. The roller shall then move inward parallel to the centre line of the road, in successive passes uniformly lapping preceding tracks by at least one half width.

Rolling shall be discontinued when the aggregates are partially compacted with sufficient void space in them to permit application of screenings. However, where screenings are not to be applied, as in the case of crushed aggregates like brick metal, laterite and kankar, compaction shall be continued until the aggregates are thoroughly keyed. During rolling, slight sprinkling of water may be done, if necessary. Rolling shall not be done when the subgrade is soft or yielding or when it causes a wave-like motion in the subgrade or sub-base course.

The rolled surface shall be checked transversely and longitudinally, with templates and any irregularities corrected by loosening the surface, adding or removing necessary amount of aggregates and re-rolling until the entire surface conforms to desired crossfall (camber) and grade. In no case shall the use of screenings be permitted to make up depressions.

Material which gets crushed excessively during compaction or becomes segregated shall be removed and replaced with suitable aggregates.

It shall be ensured that shoulders are built up simultaneously along with water bound macadam courses as per clause 400.7.4.1.

**400.4.3.5 Application of screenings** - After the coarse aggregate has been rolled to clause 400.4.3.4, screenings to completely fill the interstices shall be applied gradually over the surface. These shall not be damp or wet at the time of application. Dry rolling shall be done be damp or wet at the time of application. Dry rolling shall be done while the screenings are being spread so that vibrations of the roller cause them to settle into the voids of the coarse aggregates.

The screenings shall not be dumped in piles but be spread uniformly in successive thin layers either by the spreading motions of hand shovels or by mechanical spreaders, or directly from tipper with suitable grit spreading arrangement. Tipper operating for spreading the screenings shall be so driven as not to disturb the coarse aggregate.

The screenings shall be applied at a slow and uniform rate (in three or more applications) so as to ensure filling of all voids. This shall be accompanied by dry rolling and becoming with mechanical brooms, hand-brooms or both. In no case shall the screenings be applied so

fast and thick as to form cakes or ridges on the surface in such a manner as would prevent filling of voids or prevent the direct bearing of the roller on the coarse aggregate. These operations shall continue until no more screenings can be forced into the voids of the coarse aggregate.

The spreading, rolling, and brooming of screenings shall be carried out in only such lengths of the road which could be completed within one day's operation.

**400.4.3.6 Sprinkling of water and grouting** - After the screenings have been applied, the surface shall be copiously sprinkled with water, swept and rolled. Hand brooms shall be used to sweep the wet screenings into voids and to distribute them evenly. The sprinkling, sweeping and rolling operation shall be continued, with additional screenings applied as necessary until the coarse aggregate has been thoroughly keyed, well-bonded and firmly set in its full depth and a grout has been formed of screenings. Care shall be taken to see that the base or subgrade does not get damaged due to the addition of excessive quantities of water during construction.

In case of lime treated soil sub-base, construction of water bound macadam on top of it can cause excessive water to flow down to the lime treated sub-base before it has picked up enough strength (is still "green") and thus cause damage to the sub-base layer. The laying of water bound macadam layer in such cases shall be done after the sub-base attains adequate strength, as directed by the engineer.

**400.4.3.7 Application of binding material** - After the application of screenings in accordance with clauses 400.4.3.5 and 400.4.3.6.. the binding material where it is required to be used (clause 400.4.2.7.) shall be applied successively in two or more thin layers at a slow and uniform rate. After each application, the surface shall be copiously sprinkled with water, the resulting slurry swept in with hand brooms, or mechanical brooms to fill the voids properly, and rolled during which water shall be applied to the wheels of the rollers if necessary to wash down the binding material sticking to them. These operations shall continue until the resulting slurry after filling of voids, forms a wave ahead of the wheels of the moving roller.

**400.4.3.8 Setting and drying** - After the final compaction of water bound macadam course, the pavement shall be allowed to dry overnight. Next morning hungry spots shall be filled with screenings or binding material as directed, lightly sprinkled with water if necessary and rolled. No traffic shall be allowed on the road until the macadam has set. The engineer shall have the discretion to stop hauling traffic from using the completed water bound macadam course, if in his opinion it would cause excessive damage to the surface.

The compacted water bound macadam course should be allowed to completely dry and set before the next pavement course is laid over it.



#### **400.4.4.Surface finish and quality control work**

400.4.4.1.The surface finish of construction shall conform to the requirements of clause 900.2.

400.4.4.2. Control on the quality of materials and works shall be exercised by the engineer in accordance with section 900.

400.4.4.3. The water bound macadam work shall not be carried out when the atmospheric temperature is less than 0 deg. C. in the shade.

**400.4.4.4. Reconstruction of defective macadam** - The finished surface of water bound macadam shall conform to the tolerance of surface regularity as prescribed in clause 900.2. However, where the surface irregularity of the course exceeds the tolerances or where the course is otherwise defective due to subgrade soil mixing with the aggregates, the course to its full thickness shall be scarified over the affected area, reshaped with added material or removed and replaced with fresh material as applicable and recompact. In no case shall depressions be filled up with screenings or binding material.

**400.4. Arrangement for traffic** - During the period of construction, the arrangement of traffic shall be done as per clause 100.12.

**400.4.6 Measurements for payment** - Water bound macadam shall be measured as finished work in position in cubic metres.

**400.4.7 Rate** - The contract unit rate for water bound macadam sub-base/base course shall be payable in full compensation for all components listed in clause 400.1.8 (I) to (v) including arrangement of water used in the work as approved by the engineer

## **SECTION 500**

### **GERNERAL REQUIREMENTS FOR BITUMINOUS PAVEMENT LAYERS (UPGRADED VERSION(U.V) – NOVEMBER 2000)**

500.1.1 **General** - Bituminous pavement courses shall be made using the materials described in the following specifications.

The use of machinery and equipment mentioned in various clauses of these specifications is mandatory. Details of the machinery and equipment are available in the Manual for Construction and Supervision of Bituminous Works. Equipment mandatory for any particular project shall be in accordance with the contrast specification for that project.

### **500.1.2 Materials**

**500.1.2.1 Binder** - The binder shall be an appropriate type of bituminous materials complying with the relevant Indian Standard (IS), as defined in the appropriate clauses of these specifications, or as otherwise specified herein. The choice of binder shall be stipulated in the contract or by the engineer. Where penetration grades of bitumen are specified, they are referred to by a single-figure designation in accordance with IS: 73. Thus bitumen grade 35 refers to bitumen in the penetration range 30 to 40. Where Modified Binder is specified, the clause 500.2.1 of these specifications shall apply.

**500.1.2.2 Coarse aggregates** - The coarse aggregates shall consist of crushed rock, crushed gravel or other hard material retained on the 2.36-mm sieve. They shall be clean, hard, durable, of cubical shape, free from dust and soft or friable matter, organic or other deleterious matter. Where the contractor's selected source of aggregates have poor affinity for bitumen, as a condition for the approval of that source, the bitumen shall be treated with approved anti-stripping agents, as per the manufacturer's recommendations, without additional payment. Before approval of the source, the aggregates shall be tested for stripping.

The aggregates shall satisfy the physical requirements set forth in the individual relevant clause for the material in question.

Where crushed gravel is proposed for use as aggregate, not less than 90% by weight of the crushed material retained on the 4.75 mm sieve shall have at least two fractured faces.

### **500.1.2.3 Fine aggregates**

Fine aggregates shall consist of crushed or naturally occurring material, or a combination of the two, passing 2.36 mm sieve and retained on the 75 micron sieve. They shall be clean, hard, durable, dry and free from dust, and soft or friable matter, organic or other deleterious matter.

### **500.1.2.4 Source of material**

The source of all materials to be used on the project must be tested to the satisfaction of and be expressly approved by the engineer. The engineer from time to time withdraws approval of a specific source, or attaches conditions to the existing approval. Any change in aggregate source for bituminous mixes will require a new mix design, and laying trials, where the mix is based on a job mix design. Stockpiles from different sources, approved or otherwise, shall be kept separate, such that there is no contamination between one material and another. Each source submitted for approval shall contain sufficient material for at least 5 days work.

### **500.1.3 Mixing**

Pre-mixed bituminous materials. Including bituminous macadam, dense concrete, shall be prepared in a hot mix plant of adequate capacity and capable of yielding a mix of proper and uniform quality with thoroughly coated aggregates. Appropriate mixing temperatures can be

found in Table 500-5 of these specifications; the difference in temperature between the binder and aggregates should at not exceed 14<sup>0</sup>C. in order to ensure uniform quality of the mix and better coating of aggregates, the hot mix plant shall be calibrated from time to time.

If a continuous mixing plant is to be used for mixing the bituminous bound macadam, the contractor must demonstrate by laboratory analysis that the cold feed combined grading is within the grading limits specified for that bituminous bound material. In the case of a designed job mix, the bitumen and filler content shall be derived using this combined grading.

**500.1.4 Transporting** - Bituminous materials shall be transported in clean insulated vehicles, and unless otherwise agreed by the engineer, shall be covered while in transit or awaiting tipping. Subject to the approval of the engineer, a thin coating of diesel or lubricating oil may be applied to the interior of the vehicle to prevent sticking and to facilitate discharge of the material.

#### **500.1.5 Laying**

**500.1.5.1 Weather and seasonal limitations** - Laying shall be suspended while free standing water is present on the surface to be covered, or during rain, fog and dust storms. After rain, the bituminous surface, prime or tack coat, shall be blown off with a high-pressure air jet to remove excess moisture, or the surface left to dry before laying shall start. Laying of bituminous mixtures shall not be carried out when the air temperature at the surface on which it is to be laid is below 10<sup>0</sup>C or when the wind speed at any temperature exceeds 40 km/h at 2m height unless specifically approved by the engineer.

#### **500.1.5.2 Cleaning of surface**

The surface on which the bituminous work is to be laid shall be cleaned of all loose and extraneous matter by means of a mechanical broom or any other approved equipment/method as specified in the contract. The use of a high pressure air jet from a compressor to remove dust or loose matter shall be available full time on the site, unless otherwise specified in the contract.

#### **500.1.5.3 Spreading**

Except in areas where a mechanical paver cannot access, bituminous materials shall be spread, levelled and tamped by an approved self-propelled paving machine. As soon as possible after arrival at site, the materials shall be supplied continuously to the paver and laid without delay.

The rate of delivery of material to the paver shall be regulated to enable the paver to operate continuously. The travel rate of the paver, and its method of operations, shall be adjusted to ensure an even and uniform flow of bituminous material across the screed, free from dragging, tearing and segregation of the material. In areas with restricted space where a mechanical paver cannot be used, the material shall be spread, raked and leveled with suitable hand tools by experienced staff, and compacted to the satisfaction of the engineer.

The minimum thickness of material laid in each paver pass shall be in accordance with the minimum values given in the relevant parts of these specifications. When laying binder course or wearing course approaching expansion joint of a structure, machine laying shall stop 300 mm short of the joint. The remainder of the pavement up to joint, and the corresponding area beyond it, shall be laid by hand, and the joint or joint cavity shall be kept clear of surfacing material.

Bituminous material, with a temperature greater than 145°C, shall not be laid or deposited on bridge deck waterproofing systems, unless precautions against heat damage have been approved by engineer.

Hand placing of pre-mixing bituminous materials shall only be permitted in the following circumstances:

- (i) For laying regulating courses of irregular shape and varying thickness.
- (ii) In confined spaces where it is impracticable for a paver to operate.
- (iii) For footways.
- (iv) At the approaches to expansion joints at bridges, viaducts or other structures.
- (v) For laying mastic asphalt in accordance with clause 500.15.
- (vi) For filling of potholes.
- (vii) Where directed by the engineer

Manual spreading of pre-mixed wearing course material or the addition of such material by hand-spreading to the paved area, for adjustment of level, shall only be permitted in the following circumstances.

- (i) At the edges of the layers of material and at gullies and manholes.
- (ii) At the approaches to expansion joints at bridges, viaducts or other structures
- (iii) As directed by the engineer.

#### **500.1.5.2 Cleanliness and overlaying**

Bituminous material shall be kept clean and uncontaminated. The only traffic permitted to run on bituminous material to be overlaid shall be that engaged in laying and compacting the next course or, where a binder course is to be sealed or surface dressed, that engaged on such surface treatment. Should any bituminous material become contaminated the contractor shall make it good to the satisfaction of the engineer, in compliance with clause 500.1.8.

Binder course material shall not remain uncovered by either the wearing course or surface treatment, whichever is specified in the contract, for more than three consecutive days after being laid. The engineer may extend this period, by the minimum amount of time necessary, because of weather conditions or for any other reason. If the surface of the base course is subjected to traffic, or not covered within three days, a tack coat shall be applied, as directed by the engineer.

**500.1.6 Compaction** - Bituminous materials shall be laid and compacted in layers which enable the specified thickness, surface level, regularity requirement and compaction to be achieved.

Compaction of bituminous materials shall commence as soon as possible after laying. compaction shall be substantially completed before the temperature falls below the minimum rolling temperatures stated in the relevant part of these specifications. Rolling of the longitudinal joints shall be done immediately behind the paving operation. After this, rolling shall commence at the edges and progress onwards the centre longitudinally except that on super elevated and unidirectional cambered portions, it shall progress from the lower to the upper edge parallel to the centre line of the pavement. Rolling shall continue until all roller marks have been removed from the surface. All deficiencies in the surface after laying shall be made good by the attendants behind the paver, before initial rolling is commenced. The initial or breakdown rolling shall be done with 8 – 10 tonnes dead weight smooth-wheeled rollers. The intermediate rolling shall be done with 8-10 tonnes dead weight or vibratory roller or with a pneumatic tyred roller of 12 to 15 tonnes weight having nine wheels, with a tyre pressure of at least 5.6 kg/sqcm. The finish rolling shall be done with 6 to 8 tonnes smooth wheeled tandem rollers.

Where compaction is to be determined by density of cores the requirements to prove the performance of the rollers shall apply in order to demonstrate that the specified density can be achieved. In such cases the contractor shall nominate the plant, and the method by which he intends to achieve the specified level of compaction and finish at temperatures above the minimum specified rolling temperature/. Laying trials shall then demonstrate the acceptability of the plant and method used.

Bituminous materials shall be rolled in a longitudinal direction, with the driven rolls nearest the paver. The roller shall first compact material adjacent to joints and then work from the lower to the upper side of the layer, overlapping on successive passes by at least one-third of the width of the rear roll or, in the case of pneumatic tyred roller, at least the nominal width of 300 mm.

In portions with super-elevated and uni-directional camber, after the edge has been rolled, the roller shall progress from the lower to the upper edge.

Rollers should move at a speed of not more than 5 km per hour. The roller shall not be permitted to stand on pavement which has not been fully compacted, and necessary precautions shall be taken to prevent dropping of oil, grease, petrol or other foreign matter on the pavement either when the rollers are operating or standing. The wheels of rollers shall be kept moist with water, and the spray system provided with the machine shall be in

good working order, to prevent the mixture from adhering other wheels. Only sufficient moisture to prevent adhesion between the wheels of rollers and the mixture should be used. Surplus water shall not be allowed to stand on the partially compacted pavement.

#### **500.1.7 Joints**

Where longitudinal joints are made in pre-mixed bituminous materials, the materials shall be fully compacted and the joint made flush in one of the following ways; only method (iii) shall be used for transverse joints:

- i) by heating the joints with an approved joint heater when the adjacent width is being laid, but without cutting back or coating with binder. The heater shall raise the temperature of the full depth of material, to within the specified range of minimum rolling temperature and maximum temperature at any stage for the material, for a width not less than 75 mm. The contractor shall have equipment available, for use in the event of a heater breakdown, to form joints by methods (iii).
- (ii) by using two or more pavers operating in echelon, where this is practicable, and in sufficient proximity for adjacent widths to be fully compacted by continuous rolling;
- (iii) by cutting back the exposed joint, for a distance equal to the specified layers thickness, to vertical face, discarding all loosened material and coating the vertical face completely with 80/100 penetration grade hot bitumen, or cold-applied bitumen, or polymer modified adhesive bitumen tape with a minimum thickness of 2 mm, before the adjacent width is laid.

All joints shall be offset at least 300 mm from parallel joints in the layer beneath or as directed, and in a layout approved by the engineer. Joints in the wearing course shall coincide with either the lane edge or the lane marking, which is appropriate. Longitudinal joints shall not be situated in wheel track zones.

#### **500.1.8 Preparation of surface**

**500.1.8.1 Scope** - This work shall consist of preparing an existing granular or black-topped surface bituminous course. The work shall be performed on such widths and lengths as shown on the drawings or as instructed by engineer. The existing surface shall be firm and clean, and treated with prime or tack coat as shown on the drawings as otherwise stated in the contract.

#### **200.1.8.2 Materials**

**500.1.8.2.1 For scarifying and re-laying the granular surface** - The material used shall be coarse aggregate salvaged from the scarification of the existing granular base course supplemented by fresh coarse aggregate and screenings so that aggregates and screenings thus supplemented correspond to clause 400.4: Water Bound Macadam or clause 406:Wet Mix Macadam of the Ministry's Specification for Road and Bridge Works (third revision) 1995.

**500.1.8.2.2 For patching potholes and sealing cracks** - Where the existing surface to be overlaid is bituminous, any existing potholes and cracks shall be repaired and sealed in accordance with clauses 3000.4.2 and 3000.4.3, or as directed by the engineer.

**500.1.8.2.3 For profile corrective course** - A profile corrective course for correcting the existing pavement profile shall be laid to varying thickness as shown on the drawings, or as indicated in the contract documents. The profile corrective course shall be laid to tolerances and densities as specified for wearing course if a single layer, or base course, if it is to be covered with a wearing course layer.

**500.1.8.2.4 Profile corrective course and its application** - The type of material for use as profile corrective shall be as shown on the drawings or as directed by the engineer. While it is to be laid as part of the overlays/strengthening course, the profile corrective course material shall be of the same specification as that of the overlay/strengthening course. However, if provided as a separate layer, it shall be of the specification and details given in the contract drawings.

- i) Any high spots in the existing surface shall be removed by a milling machine or other approved method, and all loose material shall be removed to the satisfaction of the engineer.
- (ii) Where the maximum thickness of profile corrective course will be not more than 40 mm,

the profile corrective course shall be constructed as an integral part of the overlay course. In other cases, the profile corrective course shall be constructed as a separate layer, adopting such construction procedures and using such equipment as approved by the engineer, to lay the specified type of material, to thickness and tolerance as specified, for the course, to be provided.

### **500.1.8.3 Construction operations**

**500.1.8.3.1 Preparing existing granular surface** - Where the existing surface is granular, all loose materials shall be removed, and the surface lightly watered where the profile corrective course to be provided as a separate layer is also granular. Where the profile corrective course of bituminous material is to be laid over the existing granular surface, the latter shall, after removal of all loose material, be primed in accordance with clause 500.2.

The surface finish of all granular layers on which bituminous works are to be placed, shall, unless otherwise specifically instructed by the engineer, be free from dust. All such layers must be capable of being swept, after the removal of any non-integral loose material, by means of a mechanical broom, without shedding significant quantities of material and dust removed by air jet, washing, or other means approved by the engineer.

After cleaning the surface shall be correct to line and level, within the tolerances specified for base course.

**500.1.8.3.2 Scarifying existing bituminous surface** - Where specified or shown on the drawings, the existing bituminous layer in the specified width shall be removed with care and without causing undue disturbance to the underlying layer; by a suitable method approved by the engineer. After removal, all loose and disintegrated material, the underlying layers that might have been disturbed should be suitably reworked and compacted to line and level. After supplementing the base material as necessary with suitable fresh stone, the compacted finished surface shall be primed in accordance with clause 500.2. Reusable materials shall be stacked as directed by the engineer within 1000 m of their origin.

**500.8.3.3 Patching of potholes and sealing of cracks** - Where the existing surface to be overlaid is bituminous, any existing potholes and cracks shall be repaired and sealed in accordance with clauses 3000.4.2 and 3000.4.3, or as directed the engineer.

**500.1.8.3.4 Laying the profile corrective course**

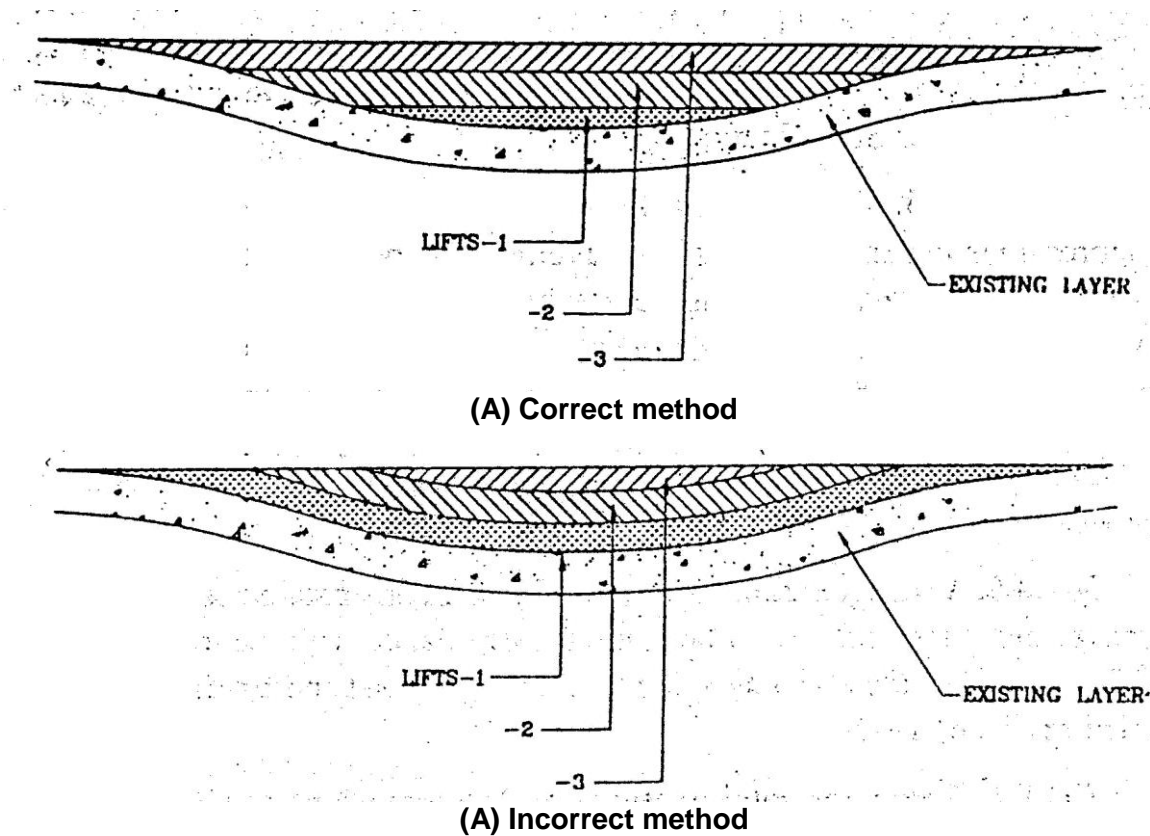
**500.8.3.4.1 Laying on granular base** - After preparing the granular surface in accordance with clauses 500.1.8.3.1 and 500.1.8.3.2, the profile corrective course shall be laid using material as described in Cluses 500.1.8.2.3 and 500.1.8.3.2.4, or otherwise described in the contract, and compacted to the requirements of the particular specifications.

**500.1.8.3.4.2 Laying on existing bituminous surface** - The existing bituminous surface shall be prepared in accordance with clause 500.1.8.3.3, and after applying a tack coat conforming to clause 500.3, the bituminous profile corrective course shall be laid and compacted to the requirements of the particular specification.

**500.1.8.3.4.3 Correction of local depression** - Where local sags or depressions occur in the existing pavement, a specific filling operation shall be instructed by the engineer, which should be laid in accordance with Figure 500-1. Normally, the maximum layer thickness at any point should not exceed 100 mm. In placing multiple lifts, they should be arranged according to the correct method as illustrated.

For correction of camber or super-elevation of the existing carriageway, the method showed in Figure. 500-2 shall be adopted, depending on the profile of the existing carriageway.





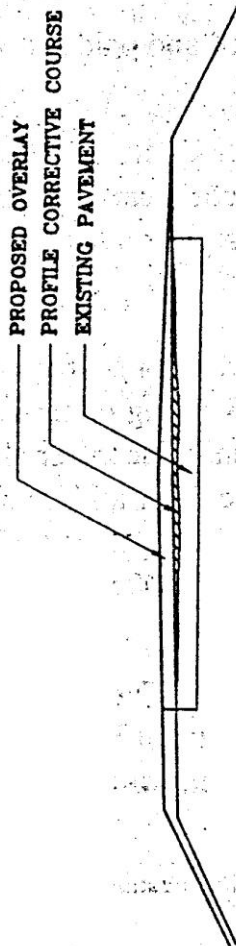
**Fig 500-1 Method for providing corrective course for short sags and depressions**

**Note:** Profile corrective course material to be in accordance with the lift thickness

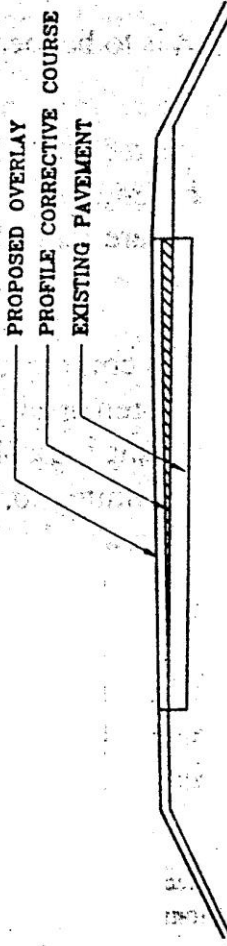
**500.1.8.3.5 Covering the profile corrective courses** - Profile corrective course particularly shall be so planned that the layer shall be covered by the designed base/wearing course at the earliest opportunity, before opening to regular traffic.

**500.1.8.4 Surface finish and quality control of work** - The relevant provisions of section 900 shall apply.

CASE I : DEFICIENCY IN CAMBER  
BERING PECTIFIED BY  
PROFILE CORRECTIVE  
COURSE



CASE II : DEFICIENCY IN SUPER  
ELEVATION BERING  
RECTIFIED BY PROFILE  
CORRECTIVE COURSE



CASE III : CONVERTING TWO-SIDE  
CAMBER TO ONE-SIDED  
CROSS-FALL DURING  
PROVISION OF A DUAL  
CARRIAGEWAY

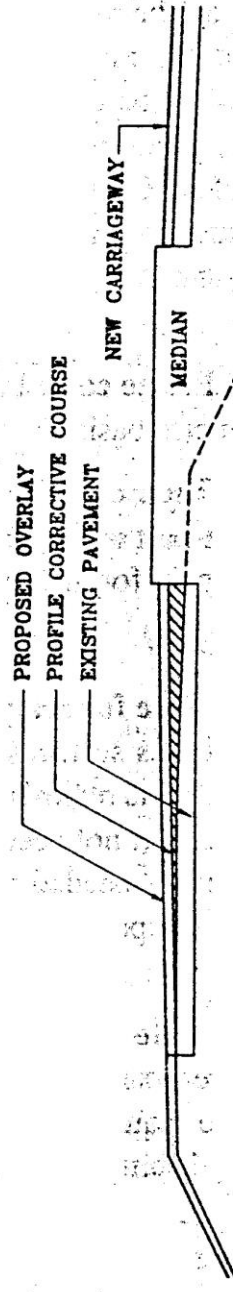


Fig 500-2 Correction of the camber of superelevation

**500.1.8.5 Arrangements for traffic** - During construction operations, arrangements for traffic shall be made in accordance with the provisions of clause 100.12.

**500.1.8.6 Environmental protection** - The provisions of clause 100.11 of the Ministry's Specification for Road and Bridge Works (third revision) 1995 and the provision of **Annexure A to clause 500.1** shall apply.

**500.1.8.7 Measurement for payment**

**500.1.8.7.1 Potholes and cracks** - The work of filling potholes shall be measured separately and be paid for in square metres.

The work of filling cracks by applying fog spray or emulsion slurry seal shall be measured in square metres, for the area covered by the spray.

The work in filling cracks larger than 3 mm in width shall be measured and paid for on a linear metre basis.

**500.1.8.7.2 Scarifying** -Scarifying the existing bituminous surface shall be measured on a square metre basis.

**500.1.8.7.3 Profile corrective course** - Profile corrective course shall be measured as the volume instructed and compacted in position and measured in cubic metres, or in tonnage, as stipulated in the contract. The volume shall be calculated by plotting the exact profile of profile corrective course as required, and laid, superimposed on the existing pavement profile. Cross-sectional areas of the profile corrective course shall be measured at intervals as used in the design, or as determined by the engineer, and the volume shall be calculated using the method of end areas.

**500.1.8.7.4 Prime coat** - Prime coat is to be measured and paid for on a per square metre basis.

**500.8.7.5 Tack coat** - This is to be a PROVISIONAL item, which may be used in-part or not at all, at the engineers direction, and is to be measured and paid for, if used, on a square metre basis.

**500.1.8.8 Rates**

**500.1.8.8.1 Rate for scarifying** - The contract unit rate for scarifying existing bituminous surfaces, including repairing/ reworking disturbed underlying layers and removing and stacking reusable/ unusable materials, shall include for but not necessarily be limited to, the cost of all labour, supply of materials needed for repair/ reworking, hire charges of tools and plant, and transportation of scarified materials within 1000 m of their origin.

**500.1.8.8.2 Rate for premixed bituminous material** - The contract unit rate for premixed bituminous material shall be payment in full for carrying out the required operations including full compensation for, but not necessarily limited to:

- (i) Making arrangements for traffic to clause 100.12 except for initial treatment to verge, shoulders and construction of diversions;
- (ii) Preparation of the surface to receive the material.
- (iii) Providing all materials to be incorporated in the work including arrangement for stockyards, all royalties, fees, and rents where necessary and all leads and lifts;
- (iv) Mixing, transporting, laying and compacting the mix, as specified.
- (v) All labour, tools, equipment, plant including installation of hot mix plant, power supply units and all machinery, incidental to complete the work to these specifications;
- (vi) Carrying out the work in part widths of the road where directed;
- (vii) Carrying out all tests for control quality; and
- (viii) The rate shall cover the provision of bitumen at the rate specified in the contract, with the provision that the variation in actual percentage of bitumen used will be assessed and the payment adjusted accordingly.
- (ix) The rates for premixed materials are to include for all wastage in cutting of joints etc.
- (x) The rates are to include for all necessary testing, mix design, transporting and testing of samples, and cores. If there is not a project specific laboratory, the contractor must arrange to carry out all necessary testing at an outside Laboratory, approved by the engineer, and all costs incurred are deemed to be included in the rate quoted for the material.
- (xi) The cost of all plant and laying trials as specified to prove the mixing and laying methods is deemed to be included in the contractor's rates for the material.

**500.1.8.8.3 Rate for potholes and crack sealing** - The rate for patching potholes shall include for breaking out, trimming edges, cleaning out, painting edges and bottom with bitumen, and filling and compacting the excavation with the specified material. The rate should be inclusive of all plant, tools, labour and materials, transport, and disposal of surplus material.

The contract unit rate for sealing cracks by applying fog spray shall be inclusive of providing all materials, tools, labour and plant and carrying out the work. The contract unit rate for sealing cracks by providing emulsion slurry seal shall be as set forth in clause 500.16.9.

The contract unit rate for crack sealing 3 mm to 6 mm cracks with straight run or other specified bitumen, shall be based on either a square metre basis, or linear metre of cracks as measured, as stipulated by the contract.

The contract unit rate for cracks between 6mm and 15 mm is to be measured on a linear metre basis, and the rate is to include for all materials, tools, plant, labour, and transport.

## **Annexure 'A'**

### **SPECIFICATIONS FOR PROTECTION OF THE ENVIRONMENT**

#### **1. General**

1.1 This section of the specifications sets out limitations on the contractor's activities specifically intended to protect the environment.

1.2 The contractor shall take all necessary measures and precautions and otherwise ensure that the execution of the works and all associated operations on site or off-site are carried out in conformity with statutory and regulatory environmental requirements including those prescribed elsewhere in this document.

1.3 The contractor shall take all measures and precautions to avoid any nuisance or disturbance arising from the execution of the works. This shall wherever possible be achieved by suppression of the nuisance at source rather than abatement of the nuisance once generated.

1.4 In the event of any spoil, debris, waste or any deleterious substance from the Site being deposited on any adjacent land, the contractor shall immediately remove all such material and restore the affected area to its original state to the satisfaction of the engineer.

#### **2. Water quality**

2.1 The contractor shall prevent any interference with the supply to or abstraction from, and prevent any pollution of, water resources (including underground percolating water) as a result of the execution of the works.

2.2 Areas where water is regularly or repetitively used for dust suppression purposes shall be laid to fall to specially constructed settlement tanks to permit sedimentation of particulate matter. After settlement, the water may be re-used for dust suppression and rinsing.

2.3 All water and other liquid waste products arising on the site shall be collected and disposed of at a location on or off the site and in a manner that shall not cause either nuisance or pollution.

2.4 The contractor shall not discharge or deposit any matter arising from the execution of the works into any waters except with the permission of the engineer and the regulatory authorities concerned.

2.5 The contractor shall at all times ensure that all existing stream courses and drains within, and adjacent to, the site are kept safe and free from any debris and any materials arising from the works.

2.6 The contractor shall protect all watercourses, waterways, ditches, canals, drains, lakes and the like from pollution as a result of the execution of the works.

### **3. Air quality**

3.1 The contractor shall devise and arrange methods of working to minimise dust, gaseous or other air-borne emissions and carry out the works in such a manner as to minimise adverse impacts on air quality.

3.2 The contractor shall utilise effective water sprays during delivery, manufacture, processing and handling of materials when dust is likely to be created, and to dampen stored materials during dry and windy weather. Stockpiles of friable materials shall be covered with clean tarpaulins, with application of sprayed water during dry and windy weather. Stockpiles of material or debris shall be dampened prior to their movement, except where this is contrary to the specification.

3.3 Any vehicle with an open load-carrying area used for transporting potentially dust-producing material shall have properly fitting side and tailboards. Materials having the potential to produce dust shall not be loaded to a level higher than the side and tail boards, and shall be covered with a clean tarpaulin in good condition. The tarpaulin shall be properly secured and extend at least 300 mm over the edges of the side and tailboards.

3.4 In the event that the contractor is permitted to use gravel or earth roads for haulage, he shall provide suitable measures for dust palliation, if these are, in the opinion of the engineer, necessary. Such measures may include spraying the road surface with water at regular intervals.

### **4. Noise**

4.1 The contractor shall consider noise as an environmental constraint in his planning and execution of the works.

4.2 The contractor shall take all necessary measures so that the operation of all mechanical equipment and construction processes on and off the site shall not cause any unnecessary or excessive noise, taking into account applicable environment requirements. The contractor shall use all necessary measures and shall maintain all plant and silencing equipment in good condition so as to minimise the noise emission during construction works.

### **5. Control of wastes**

5.1 The contractor shall control the disposal of all forms of waste generated by the construction operations and in all associated activities. No uncontrolled deposition or dumping shall be permitted. Wastes to be so controlled shall include, but shall not be limited to, all forms of fuel and engine oils, all types of bitumen, cement, surplus aggregates, gravel's, bituminous mixtures etc. The contractor shall make specific provision for the proper disposal of these and any other waste products, conforming to local regulations and acceptable to the engineer.

### **6. Emergency response**

6.1 The contractor shall plan and provide for remedial measures to be implemented in the event of occurrence of emergencies such as spillage of oil or bitumen or chemicals.

6.2 The contractor shall provide the engineer with a statement of the measures he intends to implement in the event of such an emergency, which shall include a statement of how he intends to provide personnel adequately, trained to implement such measures.

## **7. Measurement**

7.1 No separate measurement shall be made in respect of compliance by the contractor with the provisions of this section of the specification. The contractor shall be deemed to have made allowance for such compliance with these provisions in the preparation of his prices for items of work included in the Bills of Quantities and full compensation for such compliance will be deemed to be covered by them.

### **500.2 SPECIFICATIONS FOR PRIME COAT OVER GRANULAR BASE (UV - NOV 2000)**

**500.2.1 Scope** - This work shall consist of the application of a single coat of low viscosity liquid bituminous material to a porous granular surface preparatory to the superimposition of bituminous treatment or mix.

#### **500.2.2 Materials**

**500.2.2.1 Primer** - The choice of a bituminous primer shall depend upon the porosity characteristics of the surface to be primed as classified in IRC:16, These are:

- (i) Surfaces of low porosity, such as wet mix macadam and water bound macadam,
- (ii) Surfaces of medium porosity; such as cement stabilised soil base,
- (iii) Surfaces of high porosity; such as a gravel base.

**500.2.2.2 Primer viscosity** - The type and viscosity of the primer shall comply with the requirements of IS 8887, as sampled and tested for bituminous primer in accordance with these standards. Guidance on viscosity and rate of spray is given in Table 500-1.

**TABLE 500-1.** Viscosity requirement and quantity of liquid bituminous primer

Type of surface	Kinematic viscosity of Primer at 60°C (Centistokes)	Quantity of Liquid Bituminous Material per 10 Sq.cm. (kg)
Low porosity	30-60	6 to 9
Medium porosity	70-140	9 to 12
High porosity	250-500	12 to 15

**500.2.2.3 Choice of primer** - The primer shall be bitumen emulsion, complying with IS 8887 of a type and grade as specified in the contract or as directed by the engineer. The use of medium curing cutback as per IS 217 shall be restricted only for sites at sub-zero temperatures or for emergency applications as directed by engineer.

**500.2.3 Weather and seasonal limitations** - Bituminous primer shall not be applied to a wet surface (see 500.2.4.2) or during a dust storm or when the weather is foggy, rainy or windy or when the temperature in the shade is less than 10°C. Surfaces, which are to receive emulsion primer, should be damp, but no free or standing water shall be present.

#### **500.2.4 Construction**

**500.2.4.1 Equipment** - The primer distributor shall be a self-propelled or towed bitumen pressure sprayer equipped for spraying the material uniformly at specified rates and

temperatures. Hand spraying of small areas, inaccessible to the distributor, or in narrow strips shall be sprayed with a pressure hand sprayer, or as directed by the engineer.

**500.2.4.2 Preparation of road surface** - The surface to be primed shall be prepared in accordance with clauses 500.1.8 and 900.2 as appropriate. Immediately prior to applying the primer the surface shall be carefully swept clean of dust and loose particles, care being taken not to disturb the interlocked aggregate. This is best achieved when the surface layer is slightly moist (lightly sprayed with water and the surface allowed to dry) and the surface should be kept moist until the primer is applied.

**500.2.4.3 Application of bituminous primer**- The viscosity and rate of application of the primer shall be as specified in the contract, or as determined by site trials carried out as directed by the engineer. Where a geosynthetic is proposed for use, the requirements of clauses 704.3.2 and 704.4 of the Ministry's Specification for Road and Bridge Works (third revision) 1995 shall apply. The bituminous primer shall be sprayed uniformly in accordance with clause 500.1. The method for application of the primer will depend on the type of equipment to be used, size of nozzles, pressure at the spray bar and speed of forward movement. The contractor shall demonstrate at a spraying trial, that the equipment and method to be used is capable of producing a uniform spray, within the tolerances specified.

**500.2.4.4 Curing of primer and opening to traffic** - A primed surface shall be allowed to cure for at least 24 hours or such other period as is found to be necessary to allow all the volatiles to evaporate before any subsequent surface treatment or mix is laid. Any unabsorbed primer shall first be blotted with an application of sand, using the minimum quantity possible. A primed surface shall not be opened to traffic other than the necessary to lay the next course. A very thin layer of clean sand may be applied to the surface of the primer, to prevent the primer pricking up under the wheels of the paver and the trucks delivering bituminous materials to the paver.

**500.2.4.5 Tack coat** - Over the primed surface, a tack coat should be applied in accordance with clause 500.3

**500.2.5 Quality control of work** - For control of the quality of materials supplied and the works carried out, the relevant provisions of section 900 shall apply.

**500.2.6 Arrangements for traffic** - During construction operations, arrangements for traffic shall be made in accordance with the provisions of clause 100.12.

**500.2.7 Measurement for payment** - Prime coat shall be measured in terms of surface area of application in square metres

**500.2.8 Rate** - The contract unit rate for prime coat with adjustments as described in clause 500.2.7 shall be payment in full for carrying out the required operations including full compensation for all components listed in clause 401.8(l) to (v) of the Ministry's Specification for Road and Bridge Works (third revision) 1995, and as applicable to the work specified in these specifications. Payment shall be made on the basis of the provision of prime coat at an application rate of 0.6 kg per square metre, with adjustment, plus or minus, for the variation between this amount and the actual amount approved by the engineer after the preliminary trials referred to in clause 500.2.4.3.

### **500.3 SPECIFICATIONS FOR TACK COAT (UV-NOV 2000)**

**500.3.1 Scope** - This work shall consist of the application of a single coat of low viscosity liquid bituminous material to an existing bituminous road surface preparatory to the



superimposition of a bituminous mix, when specified in the contract or instructed by the engineer.

### **500.3.2 Materials**

**500.3.2.1 Binder** - The binder used for tack coat shall be bitumen emulsion complying with IS 8887 of a type and grade as specified in the contract or as directed by the engineer. The use of cutback bitumen as per IS 217 shall be restricted only for sites at sub-zero temperatures or for emergency applications as directed by the engineer.

**500.3.3 Weather and seasonal limitations** - Bituminous material shall not be applied to a wet surface or during a dust storm or when the weather is foggy, rainy or windy or when the temperature in the shade is less than 10°C. Where the tack coat consists of emulsion, the surface shall be slightly damp, but not wet. Where the tack coat is of cutback bitumen, the surface shall be dry.

### **500.3.4 Construction**

**500.3.4.1 Equipment** - The tack coat distributor shall be a self propelled or towed bitumen pressure sprayer, equipped for spraying the material uniformly at a specified rate. Hand spraying of small areas, inaccessible to the distributor, or in narrow strips, shall be sprayed with a pressure hand sprayer, or directed by the engineer.

**500.3.4.2 Preparation of base** - The surface on which the tack coat is to be applied shall be clean and free from dust, dirt, and any extraneous material, and be otherwise prepared in accordance with the requirements of clauses 500.1.8 and 900.2 as appropriate. Immediately before the application of the tack coat, the surface shall be swept clean with a mechanical broom, and high-pressure air jet, or by other means as directed by the engineer.

**500.3.4.3 Application of tack coat** - The application of tack coat shall be at the rate specified in the contract, and shall be applied uniformly. If rate of application of tack coat is not specified in the contract then it shall be at the rate specified in Table 500-2. The normal range of spraying temperature for a bituminous emulsion shall be 20°C to 70°C and for a cutback, 50°C to 80°C if RC-70/MC-70 is used. Where a geosynthetic is proposed for use, the provisions of section 700 shall apply. The method of application of the tack coat will depend on the type of equipment to be used, size of nozzles, pressure at the spray bar, and speed of forward movement. The contractor shall demonstrate at a spraying trial, that the equipment and method to be used is capable of producing a uniform spray, within the tolerances specified.

Where the material to receive an overlay is a freshly laid bituminous layer, that has not been subjected to traffic, or contaminated by dust, a tack coat is not mandatory where the overlay is completed within two days.

TABLE 500-2. Rate of application of tack coat

Sl.No.	Type of Surface	Quantity of liquid bituminous material in Kg.per sq.m.area
i.	Normal bituminous surfaces	0.20 to 0.25
ii.	Dry and hungry bituminous surfaces	0.25 to 0.30
iii.	Granular surfaces treated with primer	0.25 to 0.30
iv.	Non bituminous surfaces	
	a) Granular base (not primed) b) Cement concrete pavement	0.35 to 0.40 0.30 to 0.35

**500.3.4.4 Curing of tack coat** - The tack coat shall be left to cure until all the volatiles have evaporated before any subsequent construction is started. No plant or vehicles shall be allowed on the tack coat other than those essential for the construction.

**500.3.5 Quality control of work** - For control of the quality of materials supplied and the works carried out, the relevant provisions of section 900 shall apply.

**500.3.6 Arrangements for traffic** - During the period of construction, arrangements for traffic shall be made in accordance with the provisions of clause 100.12.

**500.3.7 Measurement for payment** - Tack coat shall be measured in terms of surface area of application in square metres.

**500.3.8. Rate** - The contract unit rate for tack coat shall be payment in full for carrying out the required operations including for all components listed in clause 400.1.8 (I) to (v) of the Ministry's Specification for Road and Bridge Works (third revision) 1995 and as applicable to the work specified in these specifications. The rate shall cover the provision of tack coat at 0.2 kg per square metre, with the provision that the variance in actual quantity of bitumen used will be assessed and the payment adjusted accordingly.

#### **500.4 SPECIFICATIONS FOR BITUMINOUS MACADAM (UV-NOV-2000)**

**500.4.1 Scope** - This work shall consist of construction in a single course having 50mm to 100 mm thickness or in multiple courses of compacted crushed aggregates premixed with a bituminous binder on a previously prepared base to the requirements of these specifications. Bituminous macadam is more open graded than the dense graded bituminous materials described in clauses 500.7, 500.8 and 500.9.

#### **500.4.2 Materials**

**500.4.2.1 Bitumen** - The bitumen shall be paving bitumen of penetration grade complying with Indian Standard specifications for "Paving Bitumen" IS: 73, and of the penetration indicated in Table 500-4.

**500.4.2.2 Coarse aggregates** - The coarse aggregates shall consist of crushed rock, crushed gravel or other hard material retained on the 2.36 mm sieve. They shall be clean, hard, durable, of cubical shape, free from dust and soft or friable matter, organic or other deleterious matter where the contractor's selected source of aggregates have poor affinity for bitumen, as a condition for the approval of that source, the bitumen shall be treated with approved anti-stripping agents, as per the manufacturer's recommendations, without additional payment. Before approval of the source, the aggregates shall be tested for stripping.

The aggregates shall satisfy the physical requirements set forth in Table 500-3.

Table 500-3. Physical requirements for coarse aggregates for bituminous macadam

Property	Test	specification
Cleanliness	Grain size analysis <sup>1</sup>	Max 5% passing 0.075 mm sieve
Particle shape	Flakiness and Elongation Index (Combined) <sup>2</sup>	Max 30%
Strength*	Los Angeles Abrasion Value <sup>3</sup>	Max 40%
	Aggregate Impact Value <sup>3</sup>	Max 30%
Durability	Soundness: <sup>4</sup>	
	Sodium sulphate	Max 12%
	Magnesium sulphate	Max 18%
Water absorption	Water absorption <sup>5</sup>	Max 2%
Stripping	Coating and Stripping of Bitumen	Minimum retained coating
	Aggregate Mixtures <sup>6</sup>	95%
Water Sensitivity <sup>7</sup>	Retained Tensile Strength	Min 80%

Notes:

1. IS:2386 Part 1
  2. IS: 2386 Part 1  
(the elongation test to be done only on non-flaky aggregates in the sample)
  3. IS: 2386 Part 4\*
  4. IS: 2386 Part 5
  5. IS: 2386 Part 3
  6. IS: 624c1
  7. IS: the water sensitivity test is only to be carried out if the minimum retained coating in the stripping test is less than 95%.
- \* Aggregate may satisfy requirements of either of these two tests.

Where crushed gravel is proposed for use as aggregate, not less than 90% by weight of the crushed material retained on the 4.75 mm sieve shall have at least two fractured faces.

**500.4.2.3 Fine aggregates** - Fine aggregates shall consists of crushed or naturally occurring material, or a combination of the two, passing 2.36 mm sieve and retained on 75 micron sieve. They shall be clean, hard, durable, dry and free from dust, and soft or friable matter, organic or other deleterious matter.

**500.4.2.4 Aggregate grading and binder content** - When tested in accordance with IS: 2386 Part 1 (wet sieving method), the combined aggregate grading for the particular mixture shall fall within the limits shown in Table 500-4 for the grading specified in the contract. The type and quantity of bitumen, and appropriate thickness, are also indicated for each mixture type.

**500.4.2.5 Proportioning of material** - The aggregates shall be proportioned and blended to produce a uniform mixture complying with the requirements of Table 500-4. The binder content shall be within a tolerance of  $\pm 0.3$  per cent by weight of total mixture when individual specimens are taken for quality control tests in accordance with the provisions of section 900.

### 500.4.3 Construction operations

**500.4.3.1 Weather and seasonal limitations** - The provisions of clause 500.1.5.1 shall apply.

Table 500-4. Composition of bituminous macadam

Mix designation Nominal aggregate size layer thickness	Grading 1 40 mm 80-100 mm	Grading 2 19 mm 50-75 mm
IS Sieve (mm)	Cumulative % by weight of total aggregate passing	
45	100	
37.5	90-100	
26.5	75-100	100
19	-	90-100
13.2	35-61	56-88
4.75	13-22	16-36
2.36	4-19	4-19
0.3	2-10	2-10
0.075	0-8	0-8
Bitumen content, % by weight	3.1 – 3.4	3.3 – 3.5
Bitumen grade	35 to 90	35 to 90

Notes: 1. Appropriate bitumen contents for conditions in cooler areas of India may be up to 0.5% higher subject to the approval of the engineer.

**500.4.3.2 Preparation of the base** - The base on which bituminous macadam is to be laid shall be prepared, shaped and compacted to the required profile in accordance with clauses 500.1.8 and 900.2.3 as appropriate, and a prime coat, shall be applied in accordance with clause 500.2 where specified, or as directed by the engineer.

**500.4.3.3 Tack coat** - A tack coat in accordance with clause 500.3 shall be applied as required by the contract documents, or directed by the engineer.

**500.4.3.4 Preparation and transportation of the mixture** - The provisions of clauses 500.1.3 and 500.1.4 shall apply.

**500.4.3.5 Spreading** - The provisions of clauses 500.1.5.3 shall apply.

Table 500-5. Manufacturing and rolling temperatures

Bitumen Penetration	Bitumen Mixing (°C)	Aggregate Mixing (°C)	Mixed Material (°C)	Rolling (°C)	Laying (°C)
35	160-170	160-175	170 Maximum	100 Minimum	130 Minimum
65	150-165	150-170	165 Maximum	90 Minimum	125 Minimum
90	140-160	140-165	155 Maximum	80 Minimum	115 Minimum

**500.4.3.6 Rolling** - Compaction shall be carried out in accordance with the provisions of clauses 500.1.6 and 500.1.7.

Rolling shall be continued until the specified density is achieved, or where no density is specified, until there is no further movement under the roller. The required frequency of testing is defined in clause 900.3.

**500.4.4 Surface finish and quality control of work** - The surface finish of the completed construction shall conform to the requirements of clause 900.2. For control of the quality of materials supplied and the works carried out, the relevant provisions of section 900 shall apply.

**500.4.5 Protection of the layer** - The bituminous macadam shall be covered with either the next pavement course or wearing course, as the case may be, within a maximum of forty-eight hours. If there is to be any delay, the course shall be covered by a seal coat to the requirement of clause 500.13 before opening to any traffic. The seal coat in such cases shall be considered incidental to the work and shall not be paid for separately.

**500.4.6 Arrangements for traffic** - During the period of construction, arrangements for traffic shall be made in accordance with the provisions of clause 100.12.

**500.4.7 Measurement of payment** - Bituminous macadam shall be measured as finished work in cubic metres, or by weight in metric tonnes, where used as regulating course, or square metres at the specified thickness as indicated in the contract or shown on the drawings, or as otherwise directed by the engineer.

**500.4.8. Rate** - The contract unit rate of bituminous macadam shall be payment in full for carrying out the required operations as specified. The rate shall include for, all components listed in clause 500.1.8.8.2.(i) to (xi).

## **500.5 SPECIFICATIONS FOR BITUMINOUS PENETRATION MACADAM (UV- NOV2000)**

**500.5.1 Scope** - The work shall consist of construction of one or more layers of compacted crushed coarse aggregates with alternate applications of bituminous binder and key aggregates in accordance with the requirements of these specifications to be used as a base course on roads, subject to the requirements of the overall pavement design, in conformity with the lines, grades and cross-sections shown on the drawings or as directed by the engineer. Thickness of an individual course shall be 50 mm or 75 mm, or other as specified.

## 500.5.2 Materials

**500.5.2.1 Bitumen** - The binder shall be paving bitumen of suitable penetration grade within the range of S-35 to S-90 or A-35 to A-90 (30/40 to 80/100) as per Indian Standards specifications for "Paving Bitumen" IS:73, or approved cutback satisfying the requirements of IS: 217 or 454. The actual grade of bitumen or cutback to be used shall be as specified or as directed by the engineer.

**500.5.2.2 Aggregates** - The aggregates shall satisfy the physical requirements set out in clause 500.4.2.2 and Table 500-3. The coarse and key aggregates shall conform to the grading given in Table 500-6.

**500.5.2.3 Quantities of materials** - The quantities of materials used for this work shall be as specified in Table 500-6.

## 500.5.3 Construction operations

**500.5.3.1 Weather and seasonal limitations** - The provisions of clause 500.1.5.1 shall apply.

**500.5.3.2 Equipment** - A mechanical broom, compressor, self propelled or trailed bitumen heater/distributor, mechanical aggregate spreader and 8 to 10 tonne smooth steel wheel roller or vibrating roller are required for the preparation of Penetration Macadam.

**500.5.3.3 Preparation of the base** - The base on which the penetration macadam course is to be laid shall be prepared, shaped and compacted to the specified lines, grades and sections to clauses 500.1 and 900.2 as appropriate, or as directed by the engineer. A prime coat, where specified, shall be applied over the base in accordance with clause 500.2 or as directed by the engineer. A tack coat as per clause 500.3 shall be applied.

**500.5.3.4 Spreading coarse aggregates** - The coarse aggregate shall be dry and clean and free from dust, and shall be spread uniformly and evenly at the rate specified in Table 500-6. It shall be spread by a self-propelled or tipper tail mounted aggregate spreader capable of spreading aggregate uniformly at the specified rates over the required widths. The surface of the layer shall be carefully checked with camber templates to ensure correct line and level and cross fall. The spreading shall be carried out such that the rolling and penetrating operations can be completed on the same day. Segregated aggregates or aggregates contaminated with foreign material shall be removed and replaced.

Table 500-6. Composition of penetration macadam

IS Sieve Designation (mm)	Cumulative per cent by weight of total aggregate passing			
	For 50 mm compacted Thickness		For 75 mm compacted Thickness	
	Coarse Aggregate	Key Aggregate	Coarse Aggregate	Key Aggregate
63	-	-	100	-
45	100	-	58-82	-
26.5	37-72	-	-	100
22.4	-	100	5-27	50-75
13.2	2-20	50-75	-	-
11.2	-	-	-	5-25
5.6	-	5-25	-	-
2.8	0-5	0-5	0-5	0-5
Approx. Loose aggregate quantities cu.m/m <sup>2</sup>	0.6	0.015	0.09	0.018
Binder quantity (penetration grade) <sup>(1)</sup> (kg/m <sup>2</sup> )	5		6.8	

**Note:** (1) If cutback bitumen is used, adjust binder quantity such that the residual bitumen is equal to the values in this table.

**500.5.3.5 Compaction** - After the spreading of coarse aggregates, dry rolling shall be carried out with an 8-10 tonne smooth steel wheel roller.

The requirements given in clause 500.1.6 and 500.1.7 shall apply.

After initial dry rolling, the surface shall be checked with a crown template and a 3 metre straight-edge. The surface shall not vary more than 10 mm from the template or straight edge. All surface irregularities exceeding the above limit shall be corrected by removing or adding aggregates as required.

The rolling shall continue until the compacted coarse aggregate has a firm surface true to; the cross section shown on the plans and has a texture that will allow free and uniform penetration of the bituminous material.

**500.5.3.6 Application of bituminous material** - After the coarse aggregate has been rolled and checked, the bituminous binder shall applied, at the rate given in Table 500-6, in accordance with clause 500.1, and at a temperature directed by the engineer.

At the time of applying the binder, the aggregates shall be surface dry for the full depth of the layer.

In certain circumstances, depending on the type and size of aggregate used, the engineer may direct the placing of a bed of clean sand or quarry fines, not exceeding 10 mm in thickness, on the prepared foundation before placing the coarse aggregate. The sand or fine material shall be slightly wetted, just sufficient for it to slurry up during the compaction process. Where cut back is used, if flooding of the binder occurs it should be applied in two operations, or as directed by the engineer.

**500.5.3.7 Application of key aggregates** - Immediately after the first application of bitumen, the key aggregates, which shall be clean, dry, and free from dust shall be spread uniformly over the surface by means of an approved mechanical spreader or by approved manual methods at the rate specified in Table 500-6.

Where directed by the engineer, the surface shall be swept and the quantity of key aggregate adjusted to ensure uniform application, with the entire surface voids in the coarse aggregate being filled without excess. The entire surface shall then be rolled with a 8-10 tonnes smooth steel wheel roller (or vibrating roller operating in non-vibratory mode) in accordance with the procedure specified in clause 500.5.3.5.

**500.5.4 Surface finish and quality control** - The surface finish of the completed construction shall conform to the requirements of clause 900.2. For control of the quality of materials supplied and the works carried out the relevant provisions of section 900 shall apply.

**500.5 Surfacing** - The penetration macadam shall be provided with a surfacing (binder/wearing course) within a maximum of forty-eight hours. If there is to be any delay, the penetration macadam shall be covered by a seal coat to the requirements of clause 500.13 before opening to traffic. The seal coat in such cases shall be considered incidental to the work and shall not be paid for separately.

**500.5.6 Arrangements for traffic** - During the period of construction, arrangements for traffic shall be made in accordance with the provisions of clause 100.12.

**500.5.7 Measurement for payment** - Penetration macadam base course shall be measured as finished work in square metres.

**500.5.8 Rate** - The contract unit rate for penetration macadam course shall be payment in full for carrying out the required operations including, but not necessarily limited to, all components listed in clause 500.1.8.8.2.(i) to (xi).

#### **500.6 SPECIFICATIONS FOR BUILT – UP SPRAY GROUT (UV-NOV 2000)**

**500.6.1 Scope** - This work shall consist of a two-layer composite construction of compacted crushed coarse aggregates with application of bituminous binder after each layer, and with key aggregates placed on top of the second layer, in accordance with the requirements of these specifications, to serve as a base course and in conformity with the lines, grades and cross-sections shown on the drawings or as directed by the engineer. The thickness of the course shall be 75 mm.

Built-up spray grout shall be used in a single course in a pavement structure.

#### **500.6.2 Materials**

**500.6.2.1 Bitumen** - clause 500.4.2.1 shall apply. Where permitted by the engineer, an appropriate grade of emulsion with IS 8887 may be used.

**500.6.2.2 Aggregates** - The coarse aggregate shall conform to clause 500.4.2.2.

The aggregates shall satisfy the physical requirements set out in Table 500-3. The coarse and key aggregates for built-up spray grout shall conform to the grading given in Table 500-7.

**Table 500-7. Grading requirements for coarse and key aggregates for built-up spray grout**

IS Sieve Designation (mm)	Cumulative per cent by weight of total aggregate passing	
	Coarse Aggregate	Key Aggregate
53.0	100	-
26.5	40-75	-
22.4	-	100
13.2	0-20	40-75
5.6	-	0-20
2.8	0-5	0-5

#### **500.6.3 Construction operations**

**500.6.3.1 Weather and seasonal limitations** - The provisions of clause 500.1.5.1 shall apply.

**500.6.3.2 Equipment** - The provisions of clause 500.5.3.2 shall apply.

**500.6.3.3 Preparation of base** - The base on which the built-up spray grout course is to be laid shall be prepared, shaped and compacted to the specified lines, grades and cross-sections in accordance with clauses 500.1 and 900.2 as appropriate. A prime coat shall be applied in accordance with clause 500.2 with approved primer as directed by the engineer.

**500.6.3.4 Tack coat** - A tack coat shall be applied in accordance with the procedure described in clause 500.3, as directed by the engineer.

**500.6.3.5 Spreading and rolling coarse aggregates for the first layer** - Immediately after the application of prime or tack coat, the clean, dry and dust free coarse aggregates shall be spread uniformly and evenly, by mechanical means, at the rate of 0.5 cu.m per 10.sq.m. area.

Immediately after spreading of the aggregates, the entire surface shall be rolled with an 8-10 tonnes smooth wheel steel roller. Rolling shall commence at the edges and progress towards the centre except in super elevated and uni-directional cambered portions where it shall proceed from the lower edge to the higher edge. Each pass of the roller shall uniformly overlap not less than one-third of the track made in the preceding pass.

The surface of the layer shall be carefully checked, after rolling, with a template and straight edge and shall be within the tolerances specified, and any deficiencies corrected by reworking and recompacting the layer.

Care shall be taken not to over-compact the layer.

**500.6.3.6 Application of binder – first spray** - The binder shall be heated to the temperature appropriate to the grade of bitumen approved by the engineer and sprayed on the aggregate at the rate of 15 kg/10 sq.m (measured in terms of residual bitumen content) at a uniform rate of spray by mechanical sprayers capable of spraying bitumen uniformly at the specified rates and temperatures. Excessive deposits of binder caused by stopping or starting of the sprayers or through leakage or for any other reason shall be removed and made good.

**500.6.3.7 Spreading and rolling of coarse aggregate for the second layer** - Immediately after the first application of the binder, the second layer of coarse aggregates shall be spread and rolled in accordance with the procedure detailed in clause 500.6.3.5.

**500.6.3.8 Application of binder – second spray** - The second aggregate layer shall then be sprayed with binder at the rate of 15 kg/10 sq.m. (measured in terms of residual bitumen content) in accordance with clause 500.6.3.6.

**500.6.3.9 Application of key aggregate** - Immediately after the second application of binder, key aggregates shall be spread uniformly and evenly, preferable by mechanical means, at the rate of 0.13 cu.m/10 sq.m so as to cover the surface completely. The key aggregate shall be clean, dry and free from dust and deleterious matter. If necessary, the surface shall be swept to ensure uniform application of the key aggregates. The entire surface shall then be rolled with an 8-10 tonnes smooth wheel steel roller in accordance with clause 500.6.3.5. While rolling is in progress, additional key aggregates, where required, shall be spread by hand. Rolling shall continue until the entire course is thoroughly compacted and the key aggregates are firmly in position.

**500.6.4 Surface finish and quality control** - The surface finish of construction shall conform to the requirements of clause 900.2. all materials shall comply with the requirements of the relevant provisions in section 900 of the specifications.

**500.6.5 Final surfacing** - The built-up-spray-grout shall be provided with final surfacing within a maximum of forty-eight hours. If there is to be any delay, the course shall be covered by a seal coat to the requirement of clause 500.13 before it is open to traffic. Where



the seal coat is required as a result of the selected method of performing this operation, then it shall be considered incidental to the work and shall not be paid for separately.

**500.6.6 Arrangements for traffic** - During the period of construction, arrangements for traffic shall be made in accordance with the provisions of clause 100.12.

**500.6.7 Measurement for payment** - Built-up spray grout shall be measured as finished work in square metres.

**500.6.8 Rate** - The contract unit rate for built-up spray grout shall be payment in full for carrying out the required operations as specified. The rate shall include for, but not necessarily be limited to the components listed in clause 500.1.8.8.2 (i) to (xi).

## **500.7 SPECIFICATIONS FOR DENSE GRADED BITUMINUS MACADAM (UV- NOV 2000)**

**500.7.1 Scope** - This clause specifies the construction of Dense Graded Bituminous Macadam (DBM), for use mainly, but not exclusively, in base/binder and profile corrective courses. DBM is also intended for use as road base material. This work shall consist of construction in a single or multiple layers of DBM on a previously prepared base or sub-base. The thickness of a single layer shall be 50 mm to 100 mm.

### **500.7.2 Materials**

**500.7.2.1 Bitumen** - The bitumen shall be paving bitumen of Penetration Grade complying with Indian Standard specifications for "Paving Bitumen" IS:73, and of the penetration indicated in Table 500-10 for dense bitumen macadam, or this bitumen as modified by one of the methods specified in clause 500.21, or as otherwise specified in the contract.

**500.7.2.2 Coarse aggregates** - The coarse aggregates shall consist of crushed rock, crushed gravel or other hard material retained on the 2.36-mm sieve. They shall be clean, hard, and durable, of cubical shape, free from dust and soft or friable matter, organic or other deleterious substances. Where the contractor's selected source of aggregates have poor affinity for bitumen, as a condition for the approval of that source, the bitumen manufacturer's recommendations, without additional payment. Before approval of the source, the aggregates shall be tested for stripping. The aggregates shall satisfy the physical requirements specified in Table 500-8, for dense bituminous macadam.

Where crushed gravel is proposed for use as aggregate, not less than 90% by weight of the crushed material retained on the 4.75 mm sieve shall have at least two fractured faces.

**500.7.2.3 Fine aggregates** - Fine aggregates shall consist of crushed or naturally occurring mineral material, or a combination of the two, passing the 2.36 mm sieve and retained on the 75 micron sieve. They shall be clean, hard, durable, dry and free from dust, and soft or friable matter, organic or other deleterious matter.

The fine aggregate shall have a sand equivalent value of not less than 50 when tested in accordance with the requirement of IS: 2720 (Part 37).

The plasticity index of the fraction passing the 0.425 mm sieve shall not exceed 4. When tested in accordance with IS: 2720 (Part 5).

Table 500-8. Physical requirements for coarse aggregate for dense graded bituminous macadam

Property	Test	specification
Cleanliness (dust)	Grain size analysis <sup>1</sup>	Max 5% passing 0.075 mm sieve.
Particle shape	Flakiness and Elongation Index (combined) <sup>2</sup>	Max 30%
Strength*	Los Angeles Abrasion Value <sup>3</sup>	Max 35%
	Aggregate Impact Value <sup>4</sup>	Max 27%
Durability	Soundness <sup>5</sup>	
	Sodium Sulphate	Max 12%
	Magnesium Sulphate	Max 18%
Water absorption	Water absorption <sup>6</sup>	Max 2%
Stripping	Coating and Stripping of Bitumen a Aggregate Mixtures <sup>7</sup>	Minimum retained coating 95%
Water Sensitivity**	Retained Tensile Strength <sup>8</sup>	Min 80%

Notes:

1. IS: 2386 Part 1

5. IS: 2386 Part 5

2. IS: 2386 Part 1

6. IS: 2386 Part 3

(The elongation test to be done only on non-flaky aggregates in the sample)

3. IS: 2386 Part 4\*

7. IS: 6241

4. IS: 2386 Part 4\*

8.AASHTO T283 \*\*

\* Aggregate may satisfy requirements of either of these two tests.

\*\* The water sensitivity test is only required if the minimum retained coating in the stripping test is less than 95%.

**500.7.2.4 Filler:** Filler shall consist of finely divided mineral matter such as rock dust, hydrated lime or cement approved by the engineer.

The filler shall be graded within the limits indicated in Table 500-9.

Table 500-9. Grading requirements for mineral filler

S Sieve (mm)	Cumulative per cent passing by weight of total aggregate
0.6	100
0.3	95-100
0.075	85-100

The filler shall be free from organic impurities and have a plasticity index not greater than 4. The Plasticity Index requirement shall not apply if filler is cement or lime. When the coarse aggregate is gravel, 2 percent by weight of total aggregate, shall be Portland cement or hydrated lime and the percentage of fine aggregate reduced accordingly. Cement or hydrated lime is not required when the limestone aggregate is used. Where the aggregates fail to meet the requirements of the water sensitivity test in Table 500-8, then 2 percent by total weight of aggregate, of hydrated lime shall be added without additional cost.

**500.7.2.5 Aggregate grading and binder content** - When tested in accordance with IS: 2386 Part 1 (wet sieving method), the combined grading of the coarse and fine aggregates and added filler for the particular mixture shall fall within the limits shown in Table 500-10, for dense bituminous macadam grading 1 or 2 as specified in the contract. The type and quantity of bitumen, and appropriate thickness, are also indicated for each mixture type.

Table 500-10 Composition of dense graded bituminous macadam pavement layers

Grading	1	2
Nominal thickness of aggregate	40 mm	25 mm
Layer thickness	80-100 mm	50-75 mm
IS Sieve <sup>1</sup>	Cumulative % by weight of total aggregate passing	
45	100	-
37.5	95-100	100
26.5	63-93	90-100
19	-	71-95
13.2	55-75	56-80
9.5	-	-
4.75	38-54	38-54
2.36	28-42	28-42
1.18	-	-
0.6	-	-
0.3	7-21	7-21
0.15	-	-
0.075	2-8	2-8
Bitumen content % by mass of total mix <sup>2</sup>	Min 4.0	Min 4.5
Bitumen grade	65 or 90	65 to 90

Note: 1. The combined aggregate grading shall not vary from the low limit on one sieve to the high limit on the adjacent sieve.

2. Determined by the Marshall method

### 500.7.3 Mixture design

**500.7.3.1 Requirement for the mixture** - Apart from conformity with the grading and quality requirements for individual ingredients, the mixture shall meet the requirements set out in Table 500-11.

Table 500-11. Requirements for dense graded bituminous macadam

Minimum stability (kN at 60°C)	9.0
Minimum flow (mm)	2
Maximum flow (mm)	4
Compaction level (Number of blows)	75 blows on each of the two faces of the specimen
Percent air voids	3 - 6
Percent voids in mineral aggregate (VMA)	See Table 500-12 below
Percent voids filled with bitumen (VFB)	65 - 75

The requirements for minimum per cent voids in mineral aggregate (VMA) are set out in Table 500-12.

Table 500-12. Minimum per cent voids in mineral aggregate (VMA)

Nominal Maximum Particle Size <sup>1</sup> (mm)	Minimum VMA, Percent Related to Design Air Voids, Percent <sup>2</sup>		
	3.0	4.0	5.0
9.5	14.0	15.0	16.0
12.5	13.0	14.0	15.0
19.0	12.0	13.0	14.0
25.0	11.0	12.0	13.0
37.5	10.0	11.0	12.0

**Notes:**

1. The nominal maximum particle size is one size larger than the first sieve to retain more than 10 percent.

2. Interpolate minimum voids in the mineral aggregate (VMA) for design air voids values between those listed.

**500.7.3.2 Binder content** - The binder content shall be optimized to achieve the requirements of the mixture set out in Table 500-11 and the traffic volume specified in the contract. The Marshall method for determining the optimum binder content shall be adopted as described in The Asphalt Institute Manual MS-2, replacing the aggregates retained on the 26.5 mm sieve by the aggregates passing the 26.5 mm sieve and retained on the 22.4 mm sieve, where approved by the engineer.

Where 40 mm dense bituminous macadam mixture is specified, the modified Marshall method described in MS-2 shall be used. This method requires modified equipment and procedures; particularly the minimum stability values in Table 500-11 shall be multiplied by 2.25, and the minimum flow shall be 3 mm.

**500.7.3.3 Job mix formula** - The contractor shall inform the engineer in writing, at least 20 days before the start of the work, of the job mix formula proposed for use in the works, and shall give the following details:

- (i) Source and location of all materials;
- (ii) Proportions of all materials expressed as follows where each is applicable:
  - (a) Binder type, and percentage by weight of total mixture;
  - (b) Coarse aggregate/Fine aggregate/Mineral filler as percentage by weight of total aggregate including mineral filler;
- (iii) A single definite percentage passing each sieve for the mixed aggregate;
- (iv) The individual gradings of the individual aggregate fractions, and the proportions of each in the combined gradings.
- (v) The results of tests enumerated in Table 500-11 as obtained by the contractor;
- (vi) Where the mixer is a batch mixer, the individual weights of each type of aggregate, and binder per batch.
- (vii) Test results of physical characteristics of aggregates to be used;
- (viii) Mixing temperature and compacting temperature.

While establishing the job mix formula, the contractor shall ensure that it is based on a correct and truly representative sample of the materials that will actually be used in the work and that the mixture and its different ingredients satisfy the physical and strength requirements of these specifications. Approval of the job mix formula shall be based on independent testing by the engineer for which samples of all ingredients of the mix shall be furnished by the contractor as required by the engineer.

The approved job mix formula shall remain effective unless and until a revised Job Mix Formula is approved. Should a change in the source of materials be proposed, a new job mix formula should be forwarded to the engineer for approval before the placing of the material.

**500.7.3.4 Plant trials – permissible variation in job mix formula** - Once the laboratory job mix formula is approved, the contractor shall carry out plant trials at the mixer to establish that the plant can be set up to produce a uniform mix conforming to the approved job mix

formula. The permissible variations of the individual percentages of the various ingredients in the actual mix from the job mix formula to be used shall be within the limits as specified in Table 500-13. These variations are intended to apply to individual specimens taken for quality control tests in accordance with section 900.

Once the plant trials have demonstrated the capability of the plant, and the trials are approved, the laying operation may commence. Over the period of the first month of production for laying on the works, the engineer shall require additional testing of the product to establish the reliability and consistency of the plant.

Table 500-13. Permissible variations from the job mix formula

Description	Permissible variation	
	Base/binder course	Wearing course
Aggregate passing 19mm sieve or larger	± 8%	± 7%
Aggregate passing 13.2 mm, 9.5 mm	± 7%	± 6%
Aggregate passing 4.75 mm	± 6%	± 5%
Aggregate passing 2.36 mm, 1.18mm, 0.6mm	± 5%	± 4%
Aggregate passing 0.3mm, 0.15mm	± 4%	± 3%
Aggregate passing 0.075 mm	± 2%	± 1.5%
Binder content	± 0.3%	± 0.3%
Mixing temperature	± 10 <sup>0</sup> C	±10 <sup>0</sup> C

**500.7.3.5 Laying trials** - Once the plant trials have been successfully completed and approved, the contractor shall carry out laying trials, to demonstrate that the proposed mix can be successfully laid, the compacted all in accordance with clause 500.1. the laying trial shall be carried out on a suitable area which is not to form part of the works, unless specifically approved in writing, by the engineer. The area of the laying trials shall be a minimum of 100 sq.m of construction similar to that of the project road, and it shall be in all respects, particularly compaction, the same as the project construction, on which the bituminous material is to be laid.

The contractor shall previously inform the engineer of the proposed method for laying and compacting the material. The plant trials shall then establish if the proposed laying plant, compaction plant, and methodology are capable of producing satisfactory results. The density of the finished paving layer shall be determined by taking cores, no sooner than 24 hours after laying, or by other approved method.

Once the laying trials have been approved, the same plant and methodology shall be applied to the laying of the material on the project, and no variation of either shall be acceptable, unless approved in writing by the engineer, who may at his discretion require further laying trials.

#### **500.7.4 Construction operations**

**500.7.4.1 Weather and seasonal limitations** - The provisions of clause 500.1.5.1 shall apply.

**500.7.4.2 Preparation of base** - The base on which Dense Graded Bituminous Material is to be laid shall be prepared in accordance with sections 500 and 900 as appropriate, or as directed by the engineer. The surface shall be thoroughly swept clean by a mechanical broom, and the dust removed by compressed air. In locations where mechanical broom cannot access, other approved methods shall be used as directed by the engineer.

**500.7.4.3 Geosynthetics** - Where Geosynthetics are specified in the contract this shall be in accordance with the requirements stated in section 700.

**500.7.4.4 Stress absorbing layer** - Where a stress-absorbing layer is specified in the contract, this shall be applied in accordance with the requirements of clause 500.22.

**500.7.4.5 Prime coat** - Where the material on which the dense bituminous macadam is to be laid other than a bitumen bound layer, a prime coat shall be applied, as specified, in accordance with the provisions of clause 500.2, or directed by the engineer.

**500.7.4.6 Tack coat** - Where the material on which the dense bituminous macadam is to be placed is a bitumen bound surface, a tack coat shall be applied as specified, in accordance with the provisions of clause 500.3, or directed by the engineer.

**500.7.4.7 Mixing and transportation of the mixture** - The provisions as specified in clauses 500.1.3 and 500.1.4 shall apply.

**500.7.4.8 Spreading** - The provisions of clauses 500.1.5.3 and 500.1.5.4 shall apply.

**500.7.4.9 Rolling** - The general provisions of clauses 500.1.6 and 500.1.7 shall apply, as modified by the approved laying trials. The compaction process shall be carried out by the same plant, and using the same method, as approved in the laying trials, which may be varied only with the express approval of the engineer in writing.

**500.7.5 Opening to traffic** - The newly laid surface shall not be open to traffic for at least 24 hrs after laying and completion of compaction, without the express approval of the engineer in writing.

**500.7.6 surface finish and quality control of work** - The surface finish of the completed construction shall conform to the requirements of clause 900.2. All materials and workmanship shall comply with the provisions set out in section 900 of this specification.

**500.7.7 Arrangements for traffic** - During the period of construction, arrangements for traffic shall be made in accordance with the provisions of section 100.

**500.7.8 Measurement for payment** - Dense Graded Bituminous Materials shall be measured as finished work either in cubic metres, tons or by the square metre at a specified thickness as detailed on the contract drawings, or documents, or as directed by the engineer.

**500.7.9 Rate** - The contract unit rate for Dense Graded Bituminous Macadam shall be payment in full for carrying out the all required operations as specified, and shall include, but not necessarily limited to all components listed in clause 500.1.8.8.2 (i) to (xi). The rate shall include the provision of bitumen, at 4.25 percent, by weight of the total mixture.

The variance in actual percentage of bitumen used will be assessed and the payment adjusted, up or down, accordingly.

## **500.8. SPECIFICATIONS FOR SEMI – DENSE BITUMINOUS CONCRETE(U.V-November 2000)**

**500.8.1 Scope** - This clause specifies the construction of Semi Dense Bituminous Concrete, for use in wearing/binder and profile corrective courses. This work shall consist of construction in a single or multiple layers of semi dense bituminous concrete on a previously prepared bituminous bound surface. A single layer shall be 25 mm to 100 mm in thickness.

## 500.8.2 Materials

**500.8.2.1 Bitumen** - The bitumen shall be paving bitumen of penetration grade complying with Indian Standard Specification for Paving Bitumen, IS: 73 and of the penetration indicated in Table 500-15, for semi dense bituminous concrete, or this bitumen as modified by one of the methods specified in clause 500.21, or as otherwise specified in the contract. Guidance on the selection of an appropriate grade of bitumen is given in The Manual for Construction and Supervision of Bituminous Works.

**500.8.2.2 Coarse aggregates** - The coarse aggregates shall be generally as specified in clause 500.7.2.2, except that the aggregates shall satisfy the physical requirements of Table 500.14.

**500.8.2.3 Fine aggregates** - The fine aggregates shall be all as specified in clause 500.7.2.3.

**500.8.2.4 Filler** - Filler shall be generally as specified in clause 500.7.2.4. Where the aggregates fail to meet the requirements of the water sensitivity test in Table 500.14 then 2 per cent by total weight of aggregate, of hydrated lime shall be added without additional cost.

**500.8.2.5 Aggregate grading and binder content** - When tested in accordance with IS: 2386 Part 1 (wet sieving method), the combined grading of the coarse and fine aggregates and added filler shall fall within the limits shown in Table 500-15 for gradings 1 or 2 as specified in the contract.

## 500.8.3 Mixture design

**500.8.3.1 Requirements for the mixture** - Apart from conformity with the grading and quality requirements for individual ingredients the mixture shall meet the requirements set out in Table 500-16.

Table 500-14. Physical requirements for coarse aggregate for semi dense bituminous concrete pavement layers

Property	Test	Specification
Cleanliness (dust)	Grain size analysis <sup>1</sup>	Max 5% passing 0.75 mm sieve
Particle shape	Flakiness and elongation Index (combined) <sup>2</sup>	Max 30%
Strength*	Los Angeles Abrasion Value <sup>3</sup> Aggregate Impact value <sup>4</sup>	Max 35% Max 27%
Polishing	Polished stone Value <sup>5</sup>	Min 55
Durability	Soundness <sup>6</sup> Sodium Sulphate Magnesium Sulphate	Max 12% Max 18%
Water absorption	Water absorption <sup>7</sup>	Max 2%
Stripping	Coating and stripping of bitumen aggregate mixtures <sup>9</sup>	Minimum retained coating 95%
Water sensitivity**	Retained tensile strength <sup>8</sup>	Min 80%

Notes:

1. IS:2386 Part 1

2. IS:2386 Part 1

(the elongation test may be done only on non-flaky aggregates in the samples)

3. IS: 2386 Part 4\*

4. IS: 2386 Part 4\*

5. BS: 812 Part 114

6. IS: 2386 Part 5

7. IS: 2386 Part 3

8. AASHTO T 283\*\*

9. IS: 6241

\* Aggregate may satisfy requirements of either of these two tests

\*\* the water sensitivity test is only required if the minimum retained coating in the stripping test is less than 95%.

The requirements for minimum per cent voids in mineral aggregate (VMA) are set out in Table 500-12.

**500.8.3.2 Binder content** - The binder content shall be optimised to achieve the requirements of the mixture set out in Table 500-16 and the traffic volume as specified in the contract. The Marshall method for determining the optimum binder content shall be adopted as described in the Asphalt Institute Manual MS-2, replacing the aggregates retained on the 26.5 mm sieve and retained on the 22.4 mm sieve, where approved by the engineer.

Table 500-15. Composition of semi dense bituminous concrete pavement layers

Grading	1	2
Nominal aggregate size	13 mm	10 mm
Layer Thickness	35 – 40 mm	25 – 30 mm
IS Sieve <sup>1</sup> (mm)	Cumulative % by weight of total aggregate passing	
45		
37.5		
26.5		
19	100	
13.2	90 - 100	100
9.5	70 - 90	90 - 100
4.75	35 - 51	35 - 51
2.36	24 - 39	24 - 39
1.18	15 - 30	15 - 30
0.6	-	-
0.3	9 - 19	9-19
0.15	-	-
0.075	3 - 8	3 - 8
Bitumen content % by mass of total mix <sup>2</sup>	Min 4.5	Min 5.0
Bitumen grade (pen)	65*	65*

**Notes:**

1. The combined aggregate grading shall not vary from the low limit on one sieve to the high limit on the adjacent sieve.

2. Determined by the Marshall method.

\* Only in exceptional circumstances, 80/100 penetration grade may be used, as approved by the engineer.

Table 500-16. Requirements for semi dense bituminous pavement layers

Minimum stability (kN at 60 <sup>0</sup> C)	8.2
Minimum flow (mm)	2
Maximum flow (mm)	4
Compaction level (Number of blows)	75 blows on each of the two faces of the specimen
Percent air voids	3 - 5
Percent voids in mineral aggregate (VMA)	See Table 500-12
Percent voids filled with bitumen (VFB)	65 - 78

**500.8.3.3 Job mix formula** - The procedure for formulating the job mix formula shall be generally as specified in clause 500.7.3.3 and results of tests enumerated in Table 500-16 as obtained by the contractors.



**500.8.3.4 Plant trials – permissible variation in job mix formula** - The requirements for plant trials shall be all as specified in clause 500.7.3.4, and permissible limits for variation as shown in Table 500-13.

**500.8.3.5 Laying trials** - The requirements for laying trials shall be all as specified in clause 500.7.3.5.

**500.8.4 Construction operations**

**500.8.4.1 Weather and seasonal limitations** -The provisions of clause 500.1.5.1 shall apply.

**500.8.4.2 Preparation of base** - The surface on which the Semi Dense Bituminous material is to be laid shall be prepared in accordance with clauses 500.1 and 900.2 as appropriate or as directed by engineer. The surface shall be thoroughly swept clean by mechanical broom and dust removed by compressed air. In locations where a mechanical broom cannot access, other approved methods shall be used as directed by the engineer.

**500.8.4.3 Geosynthetics** - Where Geosynthetics are specified in the contract this shall be in accordance with the requirements stated in section 700.

**500.8.4.4 Stress absorbing layer** - Where a stress-absorbing layer is specified in the contract, this shall be applied in accordance with the requirements of clause 500.22.

**500.8.4.5 Tack coat** - Where specified in the contract, or otherwise required by the engineer, a tack coat shall be applied in accordance with the requirements of clause 500.3.

**500.8.4.6 Mixing and transportation of the mixture** - The provisions as specified in clauses 500.1.3 and 500.1.4 shall apply.

**500.8.4.7 Spreading** - The general provisions of clauses 500.1.5.3 and 500.1.5.4 shall apply.

**500.8.4.8 Rolling** - The general provisions of clauses 500.1.6 and 500.1.7 shall apply, as modified by the approved laying trials. The compaction process shall be carried out by the same plant, and using the same method, as approved in the laying trials, which may be varied only with the express approval of the engineer in writing.

**500.8.5 Opening to traffic** - The newly laid surface shall not be open to traffic for at least 24 hours after laying and the completion of compaction, without the express approval of the engineer in writing.

**500.8.6 Surface finish and quality control** - The surface finish of the completed construction shall conform to the requirements of clause 900.2. All materials and workmanship shall comply with the provisions set out in section 900 of this specification.

**500.8.7 Arrangements for traffic** - During the period of construction, arrangements for traffic shall be made in accordance with the provisions of section 100.

**500.8.8 Measurement for payment** - The measurement shall be all as specified in clause 500.7.8.

**500.8.9 Rate** - The contract unit rate shall be all as specified in clause 500.7.9, except that the rate shall include the provision of bitumen at 4.75 percent, by weight of total mixture.

The variance in actual percentage of bitumen used will be assessed and the payment adjusted up or down, accordingly.

## **500.9. SPECIFICATIONS FOR BITUMINOUS CONCRETE (U.V-NOVEMBER-2000)**

**500.9.1 Scope** - This clause specifies the construction of Bituminous Concrete, for use in wearing and profile corrective courses. This work shall consist of construction in a single or multiple layers of bituminous concrete on a previously prepared bituminous bound surface. A single layer shall be 25 mm to 100 mm in thickness.

### **500.9.2 Materials**

**500.9.2.1 Bitumen** - The bitumen shall be paving bitumen of penetration grade complying with Indian Standard Specification for Paving Bitumen, IS:73 and of the penetration indicated in Table 500-18, for bituminous concrete, or this bitumen as modified by one of the methods specified in clause 500.21, or as otherwise specified in the contract. Guidance on the selection of an appropriate grade of bitumen is given in the Manual for Construction and Supervision of Bituminous Works.

**500.9.2.2 Coarse aggregates** - The coarse aggregates shall be generally as specified in clause 500.7.2.2, except that the aggregates shall satisfy the physical requirements of Table 500-17.

**500.9.2.3 Fine aggregates** - The fine aggregates shall be all as specified in clause 500.7.2.3.

**500.9.2.4 Filler** - Filler shall be generally as specified in clause 500.7.2.4. Where the aggregates fail to meet the requirements of the water sensitivity test in Table 500-17 then 2 per cent by total weight of aggregate, of hydrated lime shall be added without additional cost.

**500.9.2.5 Aggregate grading and binder content** - When tested in accordance with IS: 2386 Part 1 (wet grading method), the combined grading of the coarse and fine aggregates and added filler shall fall within the limits shown in Table 500-18 for grading 1 or 2 as specified in the contract.

### **500.9.3 Mixture design**

**500.9.3.1 Requirements for the mixture** - Apart from conformity with the grading and quality requirements for individual ingredients, the mixture shall meet the requirements set out in Table 500-19.

The requirements for minimum per cent voids in mineral aggregate (VMA) are set out in Table 500-12.

**500.9.3.2 Binder content** - The binder content shall be optimised to achieve the requirements of the mixture set out in Table 500-19 and the traffic volume as specified in the contract. The Marshall method for determining the optimum binder content shall be adopted as described in the Asphalt Institute Manual MS-2, replacing the aggregate retained on the 26.5 mm sieve and retained on the 22.4 mm sieve, where approved by the engineer.

**500.9.3.3 Job mix formula** - The procedure for formulating the job mix formula shall be generally as specified in clause 500.7.3.3 and the results of tests enumerated in Table 500-19 as obtained by the contractors.

Table 500-17. Physical requirements for coarse aggregate for bituminous concrete pavement layers

Property	Test	Specification
Cleanliness (dust)	Grain size analysis <sup>1</sup>	Max 5% passing 0.75 mm sieve
Particle shape	Flakiness and elongation Index (combined) <sup>2</sup>	Max 30% (combined) <sup>2</sup>
Strength*	Los Angeles Abrasion Value <sup>3</sup> Aggregate Impact value <sup>4</sup>	Max 30% Max 24%
Polishing	Polished Stone Value <sup>5</sup>	Min 55
Durability	Soundness <sup>6</sup> Sodium Sulphate Magnesium Sulphate	Max 12% Max 18%
Water absorption	Water absorption <sup>7</sup>	Max 2%
Stripping	Coating and Stripping of Bitumen Aggregate Mixtures <sup>9</sup>	Minimum retained coating 95%
WATER Sensitivity**	Retained Tensile Strength <sup>8</sup>	Min 80%

Notes:

1. IS:2386 Part 1

6. IS: 2386 Part 5

2. IS:2386 Part 1

7. IS: 2386 Part 3

(the elongation test may be done only on non-flaky aggregates in the samples)

3. IS: 2386 Part 4\*

8. AASHTO T 283\*\*

4. IS: 2386 Part 4\*

9. IS: 6241

5. BS: 812 Part 114

\* Aggregate may satisfy requirements of either of these two tests

\*\* The water sensitivity test is only required if the minimum retained coating in the stripping test is less than 95%.

**500.9.3.4 Plant trials – permissible variation in job mix formula** - The requirements for plant trials shall be all as specified in clause 500.7.3.4, and permissible limits for variation as shown in Table 500-13.

**500.9.3.5 Laying trials** - The requirements for laying trials shall be all as specified in clause 500.7.3.5.

**500.9.4.1 Weather and seasonal limitations** - The provisions of clause 500.1.5.1 shall apply.

Table 500-18. Composition of bituminous concrete pavement layers

Grading	1	2
Nominal aggregate size	19 mm	13 mm
Layer Thickness	50 – 65 mm	30 – 45 mm
IS Sieve <sup>1</sup> (mm)	Cumulative % by weight of total aggregate passing	
45		
37.5		
26.5	100	
19	79 - 100	
13.2	59 - 79	100
9.5	52 - 72	90 - 100
4.75	35 - 55	35 - 51
2.36	28 - 44	24 - 39
1.18	20 - 34	15 - 30
0.6	15 - 27	-
0.3	10 - 20	9-19
0.15	5 - 13	-
0.075	2 - 8	3 - 8
Bitumen content % by mass of total mix <sup>2</sup>	5.0 – 6.0	5.0 – 7.0
Bitumen grade (pen)	65	65

Notes:

1. The combined aggregate grading shall not vary from the low limit on one sieve to the high limit on the adjacent sieve.
2. Determined by the Marshall method.

Table 500-19. Requirements for bituminous pavement layers

Minimum stability (kN at 60°C)	9.0
Minimum flow (mm)	2
Maximum flow (mm)	4
Compaction level (Number of blows)	75 blows on each of the two faces of the specimen
Percent air voids	3 - 6
Percent voids in mineral aggregate (VMA)	See Table 500-12
Percent voids filled with bitumen (VFB)	65 - 75
Loss of stability on immersion in water at 60°C (ASTM D 1075)	Min. 75 percent retained strength

**500.9.4.2 Preparation of base** - The surface on which the bituminous concrete is to be laid shall be prepared in accordance with clauses 500.1 and 900.2 as appropriate, or as directed by the engineer. The surface shall be thoroughly swept clean by mechanical broom and dust removed by compressed air. In locations where a mechanical broom cannot access, other approved methods shall be used as directed by the engineer.

**500.9.4.3 Geosynthetics** - Where Geosynthetics are specified in the contract this shall be in accordance with the requirements stated in section 700.

**500.9.4.4 Stress absorbing layer** - Where a stress absorbing layer is specified in the contract, this shall be applied in accordance with the requirements of clause 500.22.

**500.9.4.5 Tack coat** - Where specified in the contract or otherwise required by the engineer, a tack coat shall be applied in accordance with the requirements of clause 500.3.

**500.9.4.6 Mixing and transportation of the mixture** - The provisions as specified in clauses 500.1.3 and 500.1.4 shall apply.

**500.9.4.7 Spreading** - The general provisions of clauses 500.1.5.3 and 500.1.5.4 shall apply.

**500.9.4.8 Rolling** - The general provisions of clauses 500.1.6 and 500.1.7 shall apply, as modified by the approved laying trials.

**500.9.5 Opening to traffic** - The newly laid surface shall not be open to traffic for at least 24 hours after laying and the completion of compaction, without the express approval of the engineer in writing.

**500.9.6 Surface finish and quality control** - The surface finish of the completed construction shall conform to the requirements of clause 900.2. All materials and workmanship shall comply with the provisions set out in section 900 of these specifications.

**500.9.7 Arrangements for traffic** - During the period of construction, arrangements for traffic shall be made in accordance with the provisions of section 100.

**500.9.8 Measurement for payment** - The measurement shall be all as specified in clause 500.7.8.

**500.9.9. Rate** - The contract unit rate shall be all as specified in clause 500.7.9, except that the rate shall include the provision of bitumen at 5.0 percent, by weight of total mixture. The variance in actual percentage of bitumen used will be assessed and the payment adjusted up or down, accordingly.

#### **500.10 SPECIFICATIONS FOR SURFACE DRESSING (U.V-November 2000)**

**500.10.1 Scope** - This work shall consist of the application of one coat or two coats of surface dressing, each coat consisting of a layer of bituminous binder sprayed on a previously prepared base, followed by a cover of stone chips rolled in to form a wearing course to the requirements of these specifications.

##### **500.10.2 Materials**

**500.10.2.1 Binder** - The binder shall have a kinematic viscosity lying in the range  $1 \times 10^4$  to  $7 \times 10^5$  centistokes at the expected range of road surface temperatures at the construction site during the period of laying. The type of binder to be used will be stated in the contract documents and shall comply with one of the following:

Paving bitumen	IS:73
Bitumen emulsion	IS: 8887

**500.10.2.2 Aggregates** - The chips shall conform to the requirements of clause 500.4.2.2., except that their water absorption shall be restricted to a maximum of 1 per cent and they shall have a Polished Stone Value, as measured by the method given in BS812 (Part 114), of not less than 60. The chips shall be single sized, clean, hard, durable, of cubical shape, free from dust and soft or friable matter, organic or other deleterious matter and conforming to one of the grading given in Table 500-21.

**500.10.2.3 Rates of spread of binder and chips** - For the purpose of pricing the Bill of Quantities the rates of spread given in Table 500-20 shall be priced.

Table 500-20. Nominal rates of spread for binder and chippings<sup>(1)</sup>

Nominal chipping size Mm	Binder (Penetration grade bitumen) Kg/m <sup>2</sup>	Chips Cum/m <sup>2</sup>
19	1.2	0.015
13	1.0	0.010
10	0.09	0.008
6	0.075	0.004

Note: 1. These rates of spread are for pricing purposes –see clause 500.10.2.3 and clause 500.10.8

2. For emulsion, these rates of spread are for the residual bitumen and appropriate adjustment must be made to determine the total quantity.

3. Refer to manual for construction and supervision of bituminous works for the procedure of determining the rates of spread of binder and chips.

**500.10.2.4 Anti-stripping agent** - Where the proposed aggregate fails to pass the stripping test then an approved adhesion agent (Appendix 5 for details) may be added to the binder in accordance with the manufacturer's instructions. The effectiveness of the proposed anti-stripping agent must be demonstrated by the contractor, before approval by the engineer.

**500.10.2.5 Pre-coated chips** - As an alternative to the use of an adhesion agent the chips may be pre-coated before they are spread except when the sprayed binder film is a bitumen emulsion. Pre-coating the chips may be carried out in any one of the two methods:

(a) Mixing them with 0.75 to 1.0 percent of paving bitumen by weight of chips in a suitable mixer, the chips being heated to 160°C and the bitumen to its application temperature. The pre-coated chips shall be allowed to cure for at least one week or until they become non-sticky and can be spread easily.

(b) Spraying the chips with a light application of creosote, diesel oil or kerosene at ambient temperature. This spraying can be done in a concrete mixer or on a belt conveying the chips from stockpile to gritting lorries.

### 500.10.3 Construction operations

**500.10.3.1 Weather and seasonal limitations** - Clause 500.1.5.1 shall apply.

Table 500-21. Grading requirements for chips for surface dressing

IS Sieve designation mm	Cumulative percent by weight of total aggregate passing for the following nominal sizes mm			
	19	13	10	6
26.5	100	-	-	-
19.0	85-100	100	-	-
13.2	0-40	85-100	100	-
9.5	0-7	0-40	85-100	100
6.3	-	0-7	0-35	85-100
4.75	-	-	0-10	-
3.35	-	-	-	0-35
2.36	0-2	0-2	0-2	0-10
0.6	-	-	-	0-2
0.075	0-1.5	0-1.5	0-1.5	0-1.5
Minimum 65 % by weight of aggregate	Passing 19 mm, retained 13.2 mm	Passing 13.2 mm, retained 9.5 mm	Passing 9.5 mm, retained 6.3 mm	Passing 6.3 mm, retained 3.35 mm

**500.10.3.2 Preparation of base** - The base on which the surface dressing is to be laid shall be prepared, shaped and conditioned to the specified lines, grade and cross section in accordance with clause 500.1 or as directed by the engineer. Prime coat, where needed, shall be provided as per clause 500.2 or as directed by the engineer. Where the existing surface shows signs of fatting up, the excess bitumen shall be removed by burning off, or manually, as specified in the contract or directed by the engineer. The bituminous surface to be dressed shall be thoroughly cleaned either by using a mechanical broom and/or compressed air, or any other approved equipment/method as specified in the contract or by the engineer. The prepared surface shall be dust free, clean and dry, (except in the case of cationic emulsion where the surface shall be damp).

**500.10.3.3 Application of binder** -The equipment and general procedures shall all be in accordance with the Manual for Construction and Supervision of Bituminous Works. The application temperature for the grade of binder used shall be as given in Table 500-22 and the rate of spray as given in 500.10.23.

Table 500-22. Spraying temperatures for binders

Binder grades	Whirling spray jets		Slot jets	
	Min ° C	Max ° C	Min ° C	Max ° C
Penetration Grades				
400/500	160	170	140	150
280/320	165	175	150	160
180/200	170	190	155	165
80/100	180	200	165	175

**500.10.3.4 Application of stone chips** - The equipment and general procedure shall all be in accordance with the Manual for Construction and Supervision of Bituminous Works. For relatively small areas of surface dressing, careful application of chips by hand may be acceptable if approved by the engineer. The rate of application of chips shall be as determined by the procedure given in the Manual for Construction and Supervision of Bituminous Works. Immediately after application of the binder, clean, dry chips (in the case of emulsion binder the chipping may be damp) shall be spread uniformly on the surface so as to cover the surface completely with a single layer of chips.

**500.10.3.5 Rolling** - Rolling of the chips should preferably be carried out by a pneumatic tyred roller in accordance with clause 500.1.6 and clause 500.1.7. traditional steel wheeled rollers tend to crush the aggregates and if their use cannot be avoided their weight should be limited t 8 tonnes. Rolling shall commence at the edges and progress towards the centre except in superelevated and uni-directional cambered portions where it shall proceed from the lower edge to the higher edge. Each pass of the roller shall uniformly overlap not less than one-third of the track made in the preceding pass. While rolling is in progress additional chips shall be spread by hand in necessary quantities required to make up irregularities. Rolling shall continue until all aggregate particles are firmly embedded in the binder and present a uniform closed surface.

**500.10.3.6 Application of second coat of surface dressing** - Where surface dressing in two coats is specified, the second coat should not be applied until the first coat has been open to traffic for 2 or 3 weeks. The surface on which the second coat is laid must be clean and free of dust. The construction operations for the second coat shall be the same as described in clauses 500.10.3.3 to 500.10.3.5.

**500.10.4 Opening to traffic** - Traffic shall not be permitted to run on any newly surface dressed area until the following day. In special circumstances, however, the engineer, may allow the road to be opened to traffic immediately after rolling, but in such cases traffic speed shall be limited to 20 km per hour until the following day.

**500.10.5 Surface finish and quality control of work** - The surface finish of construction shall conform to the requirements of clause 900.2.

For control on the quality of materials supplied and the works carried out, the relevant provisions of section 900 shall apply.

**500.10.6 Arrangements for traffic** - During the period of construction, arrangements for traffic shall be made in accordance with the provisions of clause 100.12.

**500.10.7 Measurement for payment** - Each coat of surface dressing shall be measured as finished work, for the area instructed to be covered, in square metres.

**500.10.8 Rate** - The contract unit rate for surface dressing, based on the notional rates of spread for binder and each size of chipping given in clause 500.10.2.3, which shall be adjusted, plus or minus, for the difference between the notional rates of spread and the rates of spread determined as described in the Manual for Construction and Supervision of Bituminous Works, and approved by the engineer, multiplied by the rates entered in the Bill of Quantities for binder and each size of chipping. The adjusted rate shall be payment in full for carrying out the required operations including full compensation for all components listed in clause 500.1.8.8.2 (i) to (xi).

## **500.11. SPECIFICATIONS FOR OPEN-GRADED PREMIX SURFACING (U.V-November 2000)**

### **500.11.1 Open-graded Premix Surfacing using Penetration Bitumen or Cutback.**

**500.11.1.1 Scope** - This work shall consist of the preparation, laying and compaction of an open-graded premix surfacing material of 20 mm thickness composed of small-sized aggregate premixed with a bituminous binder on a previously prepared base, in accordance with the requirements of these specifications, to serve as a wearing course.

#### **500.11.1.2 Materials**

**500.11.1.2.1 Binder** - The binder shall be a penetration bitumen of a suitable grade as specified in the contract, or as directed by the engineer, and satisfying the requirements of IS:73.

**500.11.1.2.2 Aggregate** - The aggregate shall conform to clause 500.4.2.2 except that the water absorption shall be limited to a maximum of 1 per cent. The Polished Stone Value, as measured by the test in BS 812-(Part 114), shall not be less than 55.

**500.11.1.2.3 Proportioning of materials** - The materials shall be proportioned in accordance with Table 500-23.

#### **500.11.1.3 Construction operations**

**500.11.1.3 Weather and seasonal limitations** - Clause 500.1.5.1 shall apply.

**500.11.1.3.2 Preparation of surface** - The under lying surface on which the bituminous surfacing is to be laid shall be prepared, shaped and conditioned to the specified lines, grade and cross-section in accordance with clause 500.1. A prime coat where needed shall be applied in accordance with clause 500.2 as directed by the engineer.



Table 500-23. Quantities of materials required for 10 m<sup>2</sup> of road surface for 20 mm thick open graded premix surfacing using penetration bitumen or cutback

Aggregates		
a.	Nominal Stone size 13.2 mm (passing 22.4 mm sieve and retained on 11.2 mm sieve)	0.18 m <sup>3</sup>
b.	Nominal Stone size 11.2 mm (passing 13.2 mm sieve and retained on 5.6 mm sieve)	0.09 m <sup>3</sup>
	Total	0.27 m <sup>3</sup>
Binder (quantities in terms of straight run bitumen)		
a.	For 0.18 m <sup>3</sup> of 13.2 mm nominal size stone at 52 kg bitumen per m <sup>3</sup>	9.5 kg
b.	For 0.09 m <sup>3</sup> of 11.2 mm nominal size stone at 56 kg bitumen per m <sup>3</sup>	5.1 kg
	Total	14.6 kg

**500.11.1.3.3 Tack coat** - A tack coat complying with clause 500.3, shall be applied over the base preparatory to laying of the surfacing.

**500.11.1.3.4 Preparation of premix** - Hot mix plant of appropriate capacity and type shall be used for the preparation of the mix material. The hot mix plant shall have separate dryer arrangement for heating aggregate.

The temperature of the binder at the time of mixing shall be in the range of 150°C to 163°C and that of the aggregate in the range of 155°C to 163°C provided that the difference in temperature between the binder and aggregate at no time exceeds 14°C. mixing shall be thorough to ensure that a homogeneous mixture is obtained in which all particles of the aggregates are coated uniformly and the discharge temperature of mix shall be between 130°C and 160°C.

The mix shall be immediately transported from the mixer to the point of use in suitable vehicles or hand barrows. The vehicles employed for transport shall be clean and the mix being transported covered in transit if so directed by the engineer.

**500.11.1.3.5 Spreading and rolling** - The pre mixed material shall be spread by suitable means to the desired thickness, grades and cross-fall (camber) making due allowance for any extra quantity required to fill pup depressions, if any. The cross-fall should be checked by means of camber boards and irregularities leveled out. Excessive use of blades or rakes should be avoided. As soon as sufficient length of bituminous material has been laid, rolling shall commence with 8-10 tonne rollers, smooth wheel tandem type, or other approved equipment. Rolling shall begin at the edge and progress towards the centre longitudinally, except that on superelevated and uni-directional cambered portions, it shall progress from the lower to upper edge parallel to the centre line of the pavement.

When the roller has passed over the whole area once, any high spots or depressions, which become apparent, shall be corrected by removing or adding premixed materials. Rolling shall then be continued until the entire surface has been rolled and all the roller marks eliminated. In each pass of the roller the preceding track shall be overlapped uniformly by at least 1/3 width. The roller wheels shall be kept damp to prevent the premix from adhering to the wheels. In no case shall fuel/lubricating oil be used for this purpose. Excess use of water for this purpose shall also be avoided.

Rollers shall not stand on newly laid material. Rolling operations shall be completed in every respect before the temperature of the mix falls below 100°C. Joints along and transverse to the surfacing laid and compacted earlier shall be cut vertically to their full depth

so as to expose fresh surface which shall be painted with a in coat of appropriate binder before the new mix is placed against it.

**500.11.1.3.6 Seal coat** - A seal coat conforming to clause 500.13 of the type specified in the contract shall be applied to the surface immediately after laying the surfacing.

**500.11.1.4 Opening to traffic** - No traffic shall be allowed on the road until the seal coat has been laid. After the seal coat is laid, the road may be opened to traffic according to clause 500.13.4.

**500.11.1.5 Surface finish and quality control of work** - The surface finish of construction shall conform to the requirements of clause 900.2. For control of the quality of materials supplied and the works carried out, the relevant provisions of section 900 shall apply.

**500.11.1.6 Arrangements for traffic** - During the period of construction, arrangement of traffic shall be made in accordance with the provisions of clause 100.12.

**500.11.1.7 Measurement for payment** - Open graded premix surfacing shall be measured as finished work, for the area instructed to be covered, in square metres. The area will be the net area covered, and all allowance for wastage and cutting of joints shall be deemed to be included in the rate.

**500.11.1.8 Rate** - The contract unit rate for open graded premix surfacing shall be payment in full for carrying out the required operations including full compensation for all components listed in clause 500.1.8.8.2. (i) to (xi).

## **500.11.2 Open graded premix surfacing using cationic bitumen emulsion**

**500.11.2.1 Scope** - This work shall consist of the preparation, laying and compaction of an open graded premix surfacing of 20 mm thickness composed of small sized aggregate premixed with a cationic bitumen emulsion on a previously prepared surface, in accordance with the requirements of these specifications, to serve as a wearing course.

### **500.11.2.2 Materials**

**500.11.2.2.1 Binder** - The binder for premix wearing course shall be cationic bitumen emulsion of Medium Setting (MS) grade complying with I.S.8887 and having a bitumen content 65 percent minimum by weight. For liquid seal coat RS grade of Cationic bitumen emulsion shall be used. Where expressly specified in the contract MS grade emulsion shall be used or otherwise directed by the engineer. Slow Setting (SS) grade Cationic bitumen Emulsion shall be used for premix seal coat.

**500.11.2.2.2 Aggregate** - The requirements of clause 500.11.1.2.2 shall apply.

### **500.11.2.3 Proportioning of materials**

The materials shall be proportioned as quantities given in Tables 500-24 and 500-25.

Table 500-2. 4. Quantities of aggregate for 10 M<sup>2</sup> area

<b>A)</b>	<b>Premix Carpet:</b>	
a.	Coarse aggregate nominal 13.2 mm size; passing IS 22.4 mm sieve and retained on IS 11.2 mm sieve	0.18 m <sup>3</sup>
b.	Coarse aggregate nominal 11.2 mm size; passing IS: 13.2 mm sieve and retained on IS 5.6 mm sieve	0.09 m <sup>3</sup>
B.	For seal coat: Refer to clause 500.13	

Table 500-25. Quantities of emulsion binder

		For 10 m <sup>2</sup> area
<b>A)</b>	<b>For Premix Carpet</b>	20 to 23 kg
<b>B)</b>	<b>For Seal Coat:</b>	
a.	For liquid seal coat	12 to 14 kg
b.	For premix seal coat	10 to 12 kg

#### **500.11.2.4 Construction operations**

**500.11.2.4.1 Weather and seasonal limitations** - clause 500.1.5.1 shall apply except that the minimum air temperature for laying shall be 10<sup>0</sup>C. Cationic bitumen emulsions shall not normally be stored below 0<sup>0</sup>C

**500.11.2.4.2 Preparation of surface** - The underlying surface on which the premix surfacing is to be laid shall be prepared, in accordance with the requirements of clause 500.4.3.2 for a newly primed surface, and in accordance with clause 500.7.4.2 where an existing bituminous surface is to be overlaid.

**500.11.2.4.3 Preparation of binder** - Before opening, the cationic bitumen emulsion drums shall be rolled at slow speed, to and fro, at least 5 times, for a distance of about 10 metres, to distribute any storage sedimentation.

**500.11.2.4.4 Preparation of premix** - Premixing of cationic bitumen emulsion and aggregates can be carried out in a suitable mixer such as cold mixing plant as per IS: 5435 (revised) or concrete mixer or by pay loaders in exceptional cases where approved by the engineer. Where specified in the contract continuous mixing operation shall be done either in batch or continuous hot mix plant suitable for emulsion mixes.

When using concrete mixer for preparing the premix, 0.135 cu.m (0.09 cu.m of 13.2 mm size and 0.045 cu.m of 11.2 mm .size) of aggregates per batch shall be used which quantity will cover 5 sq.m of road surface with 20 mm average thickness.

The aggregates required for one batch should be prepared adjacent to the mixer.

First the coarse aggregate of 13.2 mm size shall be placed into the mixer followed by 5 to 6.5 kg of cationic bitumen emulsion and then the 11.2 mm size aggregate shall be added, followed by 5 to 6.5 kg of cationic bitumen emulsion. After the materials have been mixed thoroughly, the mix shall be immediately transported to the laying site in suitable vehicles. Too much mixing shall be avoided.

When mixed manually by shovels, with the approval of the engineer, 0.06 cu. Of aggregates can be conveniently mixed in one heap, with appropriate quantity of emulsion. It is preferable to make the aggregates damp before mixing as it reduces the effort required for mixing and also helps to get better coating of aggregates. The 13.2 mm size aggregates and emulsion are mixed first and then the 11.2 mm size aggregates and remaining quantify of emulsion are added and mixed. Too much mixing shall be avoided.

**500.11.2.4.6 Spreading and rolling** - The premixed cationic bitumen emulsion and aggregates shall be spread within 10 minutes of applying the tack coat. All levelling, raking, etc. should be completed within 20 minutes of the time of mixing.

The mix should be spread uniformly to the desired thickness, grades and crossfall (camber) making due allowance for any extra quantity required to fill up depressions, if any. The cross fall should be checked by means of camber boards and irregularities leveled out. Too much raking is to be avoided.

The rolling shall start immediately after laying the premix. A smooth wheeled tandem roller of 8-10 tonnes shall be used, unless the engineer, based on the results of laying trials approves other compaction methods, if necessary. While rolling, wheels of roller should be clean and kept moist to prevent the premix from adhering to the wheels. In no case shall fuel/lubricating oil be used for this purpose. Use of water for this purpose shall be strictly limited to an absolute minimum.

Rolling shall commence at the edges and progress towards the centre longitudinally except in the case of superelevated and uni-directional cambered sections where rolling shall be carried out from the lower edge towards the higher edge parallel to the centre line of the road.

After one pass of roller over the whole area, depressions or uncovered spots should be corrected by adding premix material. Rolling shall be continued until the entire surface has been rolled to maximum compaction and all the roller marks eliminated. In each pass of the roller the preceding track shall be overlapped uniformly by at least 1/3 width. Roller(s) shall not stand on newly laid material. Joints both longitudinal and transverse to the road sections laid and compacted earlier, shall be cut vertically to their full depth so as to expose fresh surface which shall be painted with a thin surface coat of binder before the new mix is placed against it.

**500.11.2.4.7 Seal coat** - A seal coat, conforming to clause 500.10 or clause 500.13, as specified in the contract, shall be applied 4 to 6 hours after laying the premix carpet.

**500.11.2.5 Opening to traffic** - Traffic should not be allowed over the premix surface with or without seal coat, for 6 to 8 hours after rolling. In case of single lane roads, traffic shall be allowed onto the surface once it has reached ambient temperature, but speed must be rigorously restricted to not more than 16 km per hour. If any premix material is picked up by vehicle tyres, the spot shall be filled up by new mix. If traffic conditions permit, the road shall not be opened until a full 24 hours after laying.

**500.11.2.6 Surface finish and quality control** - The surface finish of construction shall conform to the requirements of clause 900.2.

For control of the quality of materials supplied and the works carried out, the relevant provisions of section 900 shall apply.

**500.11.2.7 Arrangements for traffic** - During the period of construction, arrangements for traffic shall be made in accordance with the provisions of clause 100.12.

**500.11.2.8 Measurement for payment** - Open graded premix carpet shall be measured as finished work, for the area specified to be covered, in square metres at the specified thickness, in cubic metres, or in tonnes weight as specified in the contract. The area will be the net area covered, and all allowances for wastage and cutting of joints shall be deemed to be included in the rate.

**500.11.2.9 Rate** - The contract unit rate for premix carpet and seal coat shall be payment in full for carrying out the required operations including full compensation for all components listed in clause 500.1.8.8.2 (i) to (xi).

Bitumen quantities are to be as stated in Table 500-23 for premix, 3.0 Kg per 10 sq.m for tack coat, 13 kg per 10 sq.m. for liquid seal coat and 11 kg per 10 sq.m. for premix seal coat. The rate will be adjusted according to actual material used.

## **500.12 SPECIFICATIONS FOR CLOSE- GRADED PREMIX SURFACING/MIXED SEAL SURFACING (U.V-November 2000)**

### **500.12.1 Scope**

500.12.1.1 This work shall consist of the preparation, laying and compaction of a close-graded premix surfacing material of 20 mm thickness; composed of graded aggregates premixed with a bituminous binder on a previously prepared surface, in accordance with the requirements of these specifications, to serve as a wearing course.

500.12.1.2 Close graded premix surfacing shall be of Type A or Type Bitumen as specified in the contract documents.

### **500.12.2 Materials**

**500.12.2.1 Binder** - The provisions of clause 500.11.1.2.1 shall apply.

**500.12.2.2 Coarse aggregates** - The provisions of clause 500.11.1.2.2 shall apply.

**500.12.2.3 Fine aggregates** - The fine aggregates shall consist of crushed rock quarry sands, natural gravel/sand or a mixture of both. These shall be clean, hard, durable, uncoated, mineral particles, dry and free from injurious, soft or flaky particles and organic or deleterious substances.

**500.12.2.4 Aggregate gradation** - The coarse and fine aggregates shall be so graded or combined as to conform to one or the other grading shown in Table 500-26, as specified in the contract.

Table 500-26. Aggregate gradation

IS Sieve Designation (mm)	Cumulative per cent by weight of total aggregate passing	
	Type A	Type B
13.2 mm	-	100
11.2 mm	100	88 - 100
5.6 mm	52 - 88	31 - 52
2.8 mm	14 - 38	5 - 25
0.090 mm	0 - 5	0 - 5

**500.12.2.5 Proportioning of materials** - The total quantity of aggregates used for Type A or Bitumen close-graded premix surfacing shall be 0.27 cubic metre per 10 square metre area. The quantity of binder used for premixing in terms of straight-run bitumen shall be 22.0 kg and 19.0 kg per 10 square metre area of Type A and Type Bitumen surfacing respectively.

**500.12.3 Construction operations** - The provisions of clause 500.11.1.3.1 through 500.11.1.3.5 shall apply.

**500.12.4 Opening to traffic** - Traffic may be allowed after completion of the final rolling when the mix has cooled down to the surrounding temperature. Excessive traffic speeds should not be permitted.

**500.12.5 Surface finish and quality control of work** - The surface finish of construction shall conform to the requirements of clause 900.2. for control on the quality of materials supplied and the works carried out, the relevant provisions of section 900 shall apply.

**500.12.6 Arrangements for traffic** - During the period of construction, arrangements for traffic shall be in accordance with the provisions of clause 100.12.

**500.12.7 Measurements for payment** - Close-graded premix surfacing, Type A or B shall be measured as finished work, for the area specified to be covered, in square metres at a

specified thickness. The area will be the net area covered, and all allowances for wastage and cutting of joints shall be deemed to be included in the rate.

**500.12.8 Rate** - The contract unit rate for close-graded premix surfacing, Type A or bitumen shall be payment in full for carrying out the required operations including full compensation for all components listed in clause 500.1.8.8.2 (i) to (xi).

### **500.13. SPECIFICATIONS FOR SEAL COAT(U.V-November 2000)**

#### **500.13.1 Scope**

500.13.1.1 This work shall consist of the application of a seal coat for sealing the voids in a bituminous surface laid to the specified levels, grade and cross fall (camber).

**500.13.1.2** Seal coat shall be of either of the two types specified below:

(A) Liquid seal coat comprising of an application of a layer of bituminous binder followed by a cover of stone chips.

(B) Premixed seal coat comprising of a thin application of fine aggregate premixed with bituminous binder.

#### **500.13.2 Materials**

**500.13.2.1 Binder** - The requirements of clauses 500.11.1.2.1 and 500.11.2.2.1 shall apply.

The quantity of bitumen per 10 square metres, shall be 9.8 kg for Type A, and 6.8 kg for Type Bitumen seal coat. Where bituminous emulsion is used as a binder the quantities for Type A and Type Bitumen seal coats shall be 15 kg and 10.5 kg respectively.

**500.13.2.2 Stone chips for type A seal coat** - The stone chips shall consist of angular fragments of clean, hard, tough and durable rock of uniform quality throughout. They should be free of soft or disintegrated stone, organic or other deleterious matter. Stone chips shall be of 6.7 mm size defined as 100 per cent passing through 11.2 mm sieve and retained on 2.36 mm sieve. The quantity used for spreading shall be 0.09 cubic metre per 10 square metre area. The chips shall satisfy the quality requirements in Table 500-3 except that the upper limit for water absorption value shall be 1 per cent.

**500.13.2.3 Aggregate for type B seal coat** - The aggregate shall be sand or grit and shall consist of clean, hard, durable, uncoated dry particles and shall be free from dust, soft or flaky/elongated material, organic matter or other deleterious substances. The aggregate shall pass 2.36-mm sieve and be retained on 180micron sieve. The quantity used for premixing shall be 0.06 cubic metres per 10 square metres area.

#### **500.13.3 Construction operations**

**500.13.3.1 Weather and seasonal limitations** - The requirements of clause 500.1.5.1 shall apply.

**500.13.3.2 Preparation of surface** - The seal coat shall be applied immediately after laying the bituminous course, which is required to be, sealed. Before application of seal coat materials, the surface shall be cleaned free of any dust or other extraneous matter.

**500.13.3.3 Construction of Type A seal coat** - Bitumen shall be heated to 150°C – 163°C and sprayed at the rate specified on the dry surface in a uniform manner with a self-propelled mechanical sprayer.

Immediately after the application of binder, stone chips, which shall be clean and dry, shall be spread uniformly at the rate specified on the surfaced preferably by means of a self-

propelled or towed mechanical fruit spreader so as to cover the surface completely. If necessary, the surface shall be brushed to ensure uniform spread of chips.

Immediately after the application of the cover material, the entire surface shall be rolled with a 8-10 smooth wheeled steel roller, 8 – 10 tonnes static weight vibratory roller, or other equipment approved by the engineer after laying trials if required. Rolling shall commence at the edges and progress towards the centre except in superelevated and uni-directional cambered portions where it shall proceed from the lower edge to the higher edge. Each pass of the roller shall uniformly overlap not less than one-third of the track made in the preceding pass. While rolling quantities required to make up irregularities. Rolling shall continue until all aggregate particles are firmly embedded in the binder and present a uniform closed surface.

**500.13.3.4 Construction of Type B seal coat** - A mixer of appropriate capacity and type approved by the engineer shall be used for preparation of the mixed material. The plant shall have separate dryer arrangements for heating aggregate.

The binder shall be heated in boilers of suitable design, approved by the engineer to the temperature appropriate to the grade of bitumen or as directed by the engineer. The aggregate shall be dry and suitably heated to a temperature between 150° c and 165° c or as directed by the engineer before these components are placed in the mixer. Mixing of binder with aggregates to the specified proportions shall be continued until the latter are thoroughly coated with the former.

The mix shall be immediately transported from the mixing plant to the point of use and spread uniformly on the bituminous surface to be sealed.

As soon as a sufficient length has been covered with the premixed material, the surface shall be rolled with an 8-10 tonne smooth-wheeled roller. Rolling shall be continued until the premixed material completely seals the voids in the bituminous course and a smooth uniform surface is obtained.

**500.13.4 Opening to traffic** - In the case of Type B seal coat, traffic may be allowed soon after final rolling when the premixed materials has cooled down to the surrounding temperature. **In the case of Type A seal coat, traffic shall not be permitted to run on any newly sealed area until the following day.** In special circumstances, however, the engineer may open the road to traffic immediately after rolling, but in such cases traffic speed shall be rigorously limited to 16 km per hour until the following day.

**500.13.5 Surface finish and quality control of work** - The surface finish of construction shall conform to the requirements of section 900.

For control on the quality of materials supplied and the works carried out, the relevant provisions of section 900 shall apply.

**500.13.6 Arrangements for traffic** - During the period of construction, arrangements for traffic shall be made in accordance with the provisions of section 100.

**500.13.7 Measurement for payment** - Seal coat, Type A or B shall be measured as finished work, over the area specified to be covered, in square metres at the thickness specified in the contract.

**500.13.8 Rate** - The contract unit rate for seal coat Type A or B shall be payment in full for carrying out the required operations including full compensation for all components listed in clause 500.1.8.8.2 (i) to (xi).

#### **500.14 SPECIFICATIONS FOR SUPPLY OF STONE AGGREGATES FOR PAVEMENT COURSES (U.V- November 2000)**

**500.14.1 Scope** - This specification shall apply to the supply of stone aggregates only. The work shall consist only of collection, transportation and stacking the stone aggregates and stone filler for subsequent use in pavement courses. The actual work of laying the pavement courses shall, however, be governed by the individual specification clause for the actual work, given elsewhere in this specification. The size and quantities of the aggregates to be supplied shall be so selected by the engineer that the grading requirements set forth in the individual specification clauses for the pavement courses, for which the supply is intended, are satisfied.

All the materials shall be procured from approved sources and shall conform to the physical requirements, specified in the respective specification clauses for the individual items given elsewhere in this specification.

**500.14.2 Sizes of stone aggregates** - The stone aggregates shall be designated by their standard sizes in the contract and shall conform to the requirements shown in Table 500-27.

Table 500-27. Size requirements for coarse stone aggregates

Sl.No.	Nominal size of aggregate	Designation of sieve through which the aggregates shall wholly pass	Designation of sieve on which the aggregates shall be wholly retained
i.	75 mm	106 mm	63 mm
ii.	63 mm	90 mm	53 mm
iii.	45 mm	53 mm	26.5 mm
iv.	26.5 mm	45 mm	22.4 mm
v.	22.4 mm	26.5 mm	13.2 mm
vi.	13.2 mm	22.4 mm	11.2 mm
vii.	11.2 mm	13.2 mm	6.7 mm
viii.	6.7 mm	11.2 mm	2.8 mm

#### **500.14.3 Stacking**

**1. Coarse aggregates** - Only the aggregates satisfying the specification requirements shall be conveyed to the roadside and stacked. Each size of aggregate shall be stacked separately. Likewise, materials obtained from different quarry sources shall be stacked separately and in such a manner that there is no contamination of one source with another.

**2. Fine aggregate** - As stated in the individual relevant specification clauses.

The aggregates shall be stacked entirely clear of the road way on even clear hard ground, or on a platform prepared in advance for the purpose by the contractor at his own cost and in a manner that allows correct and ready measurement. If the stockpile is placed on ground where the scraping action of the loader can contaminate the material with underlying soil, then the engineer shall reject the stockpile. Materials shall not be stacked in locations liable to inundation or flooding.

The engineer shall approve the dimensions of the stockpiles and their location. Where the material is improperly stacked, the engineer shall direct complete re-stacking of the materials in an approved manner at the contractor's cost.

Stone filler shall be supplied in a dry state in bags or other suitable containers approved by the engineer and shall be protected from the environment, so as to prevent deterioration in quality.



**500.14.4 Quality control of materials** - The engineer shall exercise control over the quality of the materials so as to ascertain their conformity with the specification requirements, by carrying out tests for the specified properties.

Testing shall be to the following frequencies and the engineer may, at his discretion, direct these to be modified according to requirements:

Coarse and fine	One test for each specified property per 50 m <sup>3</sup> of stone aggregates.
Stone filler	One test for each specified property for every five tonnes, subject to a minimum of one test for each consignment.

Materials shall only be brought to site from a previously tested and approved source, and any materials not conforming to the requirements of the specification shall be rejected by the engineer and removed from the work site.

**500.14.5 Measurement for payment** - Coarse and fine aggregates supplied to the site shall be paid for in cubic metres. The actual volume of the aggregates to be paid for shall be computed after deducting the specified percentages in Table 500-28, from the volume computed by stack measurements, to allow for bulking.

Unless otherwise directed by the engineer, measurements shall not be taken until sufficient materials for use on the road have been collected and stacked. Immediately after measurement, the stacks shall be marked by white wash or other means as directed by the engineer.

Stone filler as delivered to the site shall be measured in tonnes.

Table 500-28. Percent reduction in volume of aggregates

Sl.No.	Standard size of aggregates	Percentage reduction in volume computed by stack measurements to arrive at the volume to be paid for
1.	75 mm and 63 mm	12.5
2.	45 mm and 26.5 mm	10.0
3.	22.4 mm, 13.2 mm, 11.2 mm and 6.7 mm	5.0
4.	Fine aggregates	5.0

**500.14.6 Rates** - The contract unit rates for different sizes of coarse aggregate, fine aggregate and stone filler shall be payment in full for collecting, conveying and stacking or storing at the site including full compensation for:

(i) all royalties, fees, rents where necessary;

(ii) all leads and lifts; and

(iii) all labour, tools, equipment and incidentals to complete the work to the specifications.

(iv) all necessary testing of material, both initial, to approve the source, and regular control testing thereafter.

## **500.15. SPECIFICATIONS FOR MASTIC ASPHALT (U.V-November 2000)**

### **500.15.1 Scope**

This work shall consist of constructing a single layer of mastic asphalt wearing course for road pavements and bridge decks.

Mastic asphalt is an intimate homogeneous mixture of selected well graded aggregates, filler and bitumen in such proportions as to yield a plastic and voidless mass, which when applied hot can be trowelled and floated to form a very dense impermeable surfacing.

### **500.15.2 Materials**

**500.15.2.1 Binder** - Subject to the approval of the engineer, the binder shall be a paving grade bitumen meeting the requirements given in Table 500-29.

#### **500.15.2.2 Coarse aggregate**

The coarse aggregate shall consist of crushed stone, crushed gravel/shingle or other stones. They shall be clean, hard, durable, of fairly cubical shape, uncoated and free from soft, organic or other deleterious substances. They shall satisfy the physical requirements given in Table 500-3.

The percentage and grading of the coarse aggregate to be incorporated in the mastic asphalt depending upon the thickness of the finished course shall be as specified in Table 500-30.

Table 500-29. Requirements for physical properties of binder

Property		Test method	Requirement
Penetration at 25 <sup>o</sup> C		IS 1203	15 ± 5
Softening point, <sup>o</sup> C		IS 1205	65 ± 10
Loss on heating for 5h at 163 <sup>o</sup> C, % by mass	Max.	IS 1212	2.0
Solubility in trichloroethylene, % by mass	Min.	IS 1216	95
Ash (mineral matter), % by mass	Max.	IS 1217	1.0

Table 500-30. Grade and thickness of mastic asphalt paving, and grading of coarse aggregate

Application	Thickness range (mm)	Nominal size of coarse aggregate (mm)	Coarse aggregate content, % by mass of total mix
Roads and carriageways	25 – 50	13	40 ± 10
Heavily stressed areas i.e. junctions and toll plazas	40 – 50	13	45 ± 10
Nominal size of coarse aggregate IS Sieve (mm)	13 mm		
	Cumulative % passing by weight		
19	100		
13.2	88 – 96		
2.36	0 - 5		

**Fine aggregate** - The fine aggregate shall be the fraction passing the 2.36 mm and retained on the 0.075 mm sieve consisting of crusher run screening, natural sand or a mixture of both. These shall be clean, hard, durable, uncoated, dry and free from soft or flaky pieces and organic or other deleterious substances.

**Filler** - The filler shall be lime stone powder passing the 0.075 mm sieve and shall have a calcium carbonate content of not less than 80 percent by weight when determined in accordance with IS:1514.

They grading of the fine aggregate inclusive of filler shall be as given in Table 500-31.

Table 500-31. Grading of fine aggregate (inclusive of filler)

I.S.Sieve	Percentage by weight of aggregate
Passing 2.36 mm but retained on 0.600 mm	0 – 25
Passing 0.600 mm but retained on 0.212 mm	10 – 30
Passing 0.212 mm but retained on 0.075 mm	10 – 30
Passing 0.075	30 - 55

### 500.15.3 Mixing design

**500.15.3.1 Hardness number** - The mastic asphalt shall have a hardness number at the time of manufacture of 60 to 80 at 25°C prior to the addition of coarse aggregate and 10 to 20 at 25°C at the time of laying after the addition of coarse aggregate.

**500.15.3.2 Binder content** - The binder content shall be so fixed as to achieve the requirements of the mixture specified in clause 500.15.3.1 and shall be in the range of 14 to 17 percent by weight of total mixture as indicated in Table 500-32.

Table 500.32. Composition of mastic asphalt blocks without coarse aggregate

IS Sieve	Percentage by weight of mastic asphalt	
	Minimum	Maximum
Passing 2.36 mm but retained on 0.600 mm	0	22
Passing 0.600 mm but retained on 0.212 mm	4	30
Passing 0.212 mm but retained on 0.075 mm	8	18
Passing 0.075 mm	25	45
Bitumen content	14	17

**500.15.3.3 Job mix formula** - The contractor shall inform the engineer in writing at least 1 month before the start of the work of the job mix formula proposed to be used by him for the work, indicating the source and locating of all materials, proportions of all materials such as binder and aggregates, single definite percentage passing each sieve for the mixed aggregate and results of the tests recommended in the various Tables and clauses of this specification.

### 500.15.4 Construction operations

**500.15.4.1 Weather and seasonal limitations** - The provisions of clause 500.1.5.1 shall apply, except that laying shall not be carried out when the air temperature at the surface on which the Mastic Asphalt is to be laid is below 10°C.

**500.15.4.2 Preparation of the base** - The base on which mastic asphalt is to be laid shall be prepared, shaped and conditioned to the profile required, in accordance with clause 500.1 or 900.2 as appropriate or as directed by the engineer. In the case of a cement concrete base, the surface shall be thoroughly power brushed clean and free of dust and other deleterious matter. Under no circumstances shall mastic asphalt be spread on a base containing a binder which might soften under high application temperatures. If such material exists, the same shall be cut out and repaired before the mastic asphalt is laid.

**500.15.4.3 Tack coat** - A tack coat in accordance with clause 500.3 shall be applied on the base or as directed by the engineer.

**500.15.4.4 Preparation of mastic asphalt** - Penetration of mastic asphalt consists of two stages. The first stage shall be mixing of filler and fine aggregates and then heating the mixture to a temperature of 170°C to 210°C. Required quantity of bitumen shall be heated to 170°C to 180°C and added to the heated aggregates. They shall be mixed and cooked in an

approved type of mechanically agitated mastic cooker for some time till the materials are thoroughly mixed. Initially the filler along is to be added. After heating and mixing for some time, the fine aggregates and the balance of binder are to be added and further cooked for about one hour. The second stage is incorporation of coarse aggregates and cooking the mixture for a total period of 3 hours. During cooking and mixing, care shall be taken to ensure that the contents in the cooker are at no time heated to a temperature exceeding 210°C.

Where the material is not required for immediate use it shall be cast into blocks consisting of filler, fine aggregates and binder, but without the addition of coarse aggregate, weighing about 25 kgs each. Before use, these blocks shall be reheated to a temperature of not less than 175°C and not more than 210°C, thoroughly incorporated with the requisite quantity of coarse aggregates and mixed continuously. Mixing shall be continued until laying operations are completed so as to maintain the coarse aggregates in suspension. At no stage during the process of mixing shall the temperature exceed 210°C.

The mastic asphalt blocks (without coarse aggregate) shall show on analysis a composition within the limits as given in Table 500-32.

The mixture shall be transported to the laying site in a towed mixer transporter having arrangement for stirring and keeping the mixture hot during transportation.

**500.15.4.5 Spreading** - The mastic asphalt shall be laid, normally in one coat, at a temperature between 175°C and 210°C and spread uniformly by hand using wooden floats or by machine on the prepared and regulated surface. The thickness of the mastic asphalt and the percentage of added coarse aggregate shall be in accordance with Table 500-30 or as specified by the engineer. Where necessary, battens of the requisite dimensions should be employed. Any blowholes that appear in the surface shall be punctured while the material is hot, and the surface made good by further floating.

**500.15.4.6 Joints** - All construction joints shall be properly and truly made. These joints shall be made by warming existing mastic asphalt by the application of an excess quantity of the hot mastic asphalt mixture which afterwards shall be trimmed to leave it flush with the surfaces on either side.

500.15.4.7 The mastic asphalt surface can have poor skid resistance after floating; in order to provide resistance to skidding, the mastic asphalt after spreading, while still hot and in a plastic condition, shall be covered with a layer of stone aggregate. This aggregate shall be 13.2 mm size (passing the 19.0 mm sieve and retained on the 9.5 mm sieve) or 9.5 mm size (passing the 13.2 mm sieve and retained on the 6.7 mm sieve) subject to the approval of the engineer. Hard stone chips, complying with the quality requirements of Table 500-17, shall be precoated with bitumen at the rate of  $2 \pm 0.4\%$  of S-65 penetration grade. The addition of 2% of filler complying with Table 500-9 may be required to enable this quantity of binder to be held without draining. The chips shall then be applied at the rate of 0.005 cu.m per 10.sq.m and rolled or other wise pressed into the surface of the mastic layer when the temperature of the mastic asphalt is not less than 100°C.

**500.15.5 Opening to traffic** - Traffic may be allowed after completion of the work when the mastic asphalt temperature at the mid-depth of the completed layer has cooled to the daytime maximum ambient temperature.

**500.15.5.6 Surface finish and quality control of work** - The surface finish of the completed construction shall conform to the requirements of clause 900.2.

For control of the quality of materials supplied and the works carried out, the relevant provisions of section 900 shall apply.

The surface of the mastic asphalt, tested with a straight edge 3.0 m long, placed parallel to the centre line of the carriageway, shall have no depression greater than 7 mm. The same limit shall also apply to the transverse profile when tested with a camber template.

**500.15.5.7 Arrangements for traffic** - During the period of construction, arrangements for traffic shall be made in accordance with the provisions of clause 100.12.

**500.15.8 Measurement for payment** - Mastic asphalt shall be measured as finished work in square metres at a specified thickness, or by weight in tonnes as stated in the contract.

**500.15.9 Rate** - The contract unit rate for mastic asphalt shall be payment in full for carrying out the required operations including full compensation for all components listed under clause 500.1.8.8.2 (i) to (ix).

#### **500.16. SPECIFICATIONS FOR SLURRY SEAL (U.V-November 2000)**

**500.16.1 Scope** - Slurry seal are mixtures of fine aggregate, Portland cement filler, bitumen emulsion and additional water. When freshly mixed, they have a thick consistency and can be spread to a thickness of 1.5-5 mm. They may be used to seal cracks, arrest fretting and fill voids and minor depressions, to provide a more even riding surface or a base for further treatment; they may also be used on top of a single coat surface dressing.

**500.16.2 Materials** - The material for slurry seal immediately prior to mixing shall conform to the following requirements.

**500.16.2.1 Emulsified bitumen** - The emulsified bitumen shall be a cationic rapid setting type as approved by the engineer, conforming to the requirements of IS:8887. Where special mobile mixing machines are available, Class A4 rapid setting or Class K3 road emulsions to BS 434:Part1 should be used to obtain very early resistance to traffic and rain. Generally, emulsion for slurry seal should be capable of producing a slurry that will develop early resistance to traffic and rain and is sufficiently stable to permit mixing with the specified aggregate, without breaking during the mixing and laying processes. If approved by the engineer, a slow setting emulsion may be used.

**500.16.2.2 Water** - Water shall be of such quality that the bitumen will not separate from the emulsion before the slurry seal is in place.

The pH of the water must lie in the range 4 to 7, and if the total dissolved solids in the water amount to more than 500 ppm, the engineer may reject it, or order the contractor to conduct a trial emulsion mix to demonstrate that it does not cause early separation.

**500.16.2.3 Aggregate** - The aggregate shall be crushed rock, or slag and may be blended, if required, with clean, sharp, naturally occurring sand free from soft pieces and organic and other deleterious substances to produce a grading as given in Table 500-33. The aggregates shall meet the requirements of the film stripping test (IS:6241), and a suitable amount and type of anti-stripping agent added, as may be needed (details given in Appendix 5).

**500.16.Additives** - It is usual to use ordinary Portland cement, hydrated lime or other additives to control consistency, mix segregation and setting rate. The proportion of the additive should not normally exceed 2 per cent by weight of dry aggregates.

**500.16.3 Mixture design** - A range of residual binder contents for each aggregate grading is given in Table 500-33. The optimum mixture design for the aggregate, additive, water and bitumen emulsion mixture should be determined in accordance with ASTM D 3910.

#### **500.16.4 Construction operations**

**500.16.4.1 Weather and seasonal limitations** - Clause 500.1.5.1 shall apply.

Table 500-33. Aggregate grading, binder content and approximate coverage rate

Sieve Size (mm)	Percentage by mass passing finished thickness of sealing		
	5 mm	3 mm	1.5 mm
9.5	100	-	-
4.75	90 – 100	100	-
3.35	-	80 – 100	100
2.36	65 – 90	75 – 100	95 – 100
1.18	45 – 70	55 – 90	70 – 95
0.600	30 – 50	35 – 70	55 – 75
0.300	18 – 30	20 – 45	30 – 50
0.150	10 – 21	10 – 25	10 – 30
0.075	5 – 21	5 – 15	5 – 15
Quantity of residual binder, percentage by mass of aggregate	7.5 – 13.5	10 – 16	12 – 20
Approximate coverage rate (kg.m <sup>2</sup> )	8 – 15	4 - 6	2 - 4

**500.16.4.2 surface preparation** - Any necessary remedial work to the road surface and structure shall be completed either prior to or as part of the contract and agreed as acceptable by the engineer, according to the provisions of clause 500.1.

Before slurry seal is applied, street furniture and, where directed by the engineer, road markings, shall be masked using self-adhesive masking material or other material firmly secured against the passage of the spreader box or the tools used for hand laying. Any packed mud or other deposits on the surface shall be removed, all organic growth shall be removed by suitable means, and the surface shall be swept free of all loose material.

**500.16.4.3 Tack coat** - If required by the engineer, a tack coat may be applied prior to the slurry seal, with or without grit or chips, in order to seal the existing substrata and enhance the bond to the existing road surface. Unless otherwise agreed by the engineer, the rate of spread of tack coat shall be 0.15 to 0.30 litres/m<sup>2</sup> for bituminous surfaces and 0.4 to 0.6 litres/m<sup>2</sup> for concrete surfaces.

**500.16.4.4 Mixing and transportation of mixture** - Mixing (and laying) techniques vary according to the type of emulsion used. For class A4 rapid setting and K3 emulsions, only special mobile mixing machines should be used. These carry supplies of aggregate, emulsion, water and filler (e.g. ordinary Portland cement or hydrated lime) and are fitted with metering devices to feed the ingredients in their correct proportions to a mixer fitted to the rear of the machine. From the mixer the slurry is fed into the screed box towed by the machine.

For all other emulsions, mixing may be by hand, concrete mixer or other mixer, which effectively coats the aggregate uniformly and produces a slurry seal of suitable consistency for satisfactory laying. For large areas, a bulk transit concrete mixer may be used into which the ingredients (including water) are measured and mixed as the mixer travels to the area to be treated. A screed box fitted with an adjustable rubber screed should be towed by the mixer, which feeds it during laying.

The special mobile mixing machine, when used, shall be capable of uniform application to provide a continuous surface without ridges or segregation. Before laying begins, the contractor shall provide the engineer with a test certificate showing test results for rate of application carried out under the supervision of a competent authority, demonstrating that the machine has been tested, using the system to be used in the contract, not more than six weeks before the commencement of the work.

Where the material is to be hand laid, the slurry may be supplied to site pre-mixed in suitable containers and steps shall be taken to ensure that the material in each container is of an even consistency throughout the container immediately prior to use.

**500.16.4.5 Application** - Transverse joints for machine laid areas shall be formed with spreading, starting and finishing on a protective strip not less than 100 mm wide at each end of the lane length being treated, transverse joints shall be formed such that there shall be no ridges or bare strips.

Unless otherwise approved by the engineer, longitudinal joints shall coincide with lane markings. Longitudinal joints shall be formed such that there shall be no ridges or bare strips.

Handwork around street furniture and other obstructions should meet the same performance requirements and form a homogeneous surface with the rest of the treated carriageway.

Footways and other confined areas may be spread by hand using squeezes and brooms. Transverse joints shall be formed with spreading, starting and finishing on a protective strip not less than 100 mm wide at each end of the lane length being treated. Transverse joints shall be formed such that there shall be no ridges or bare strips. Kerb edges and other areas not being treated shall be suitably masked with self-adhesive masking material. Footways shall be finished by dragging a dampened broom transversely over the footway under its own weight.

All voids, cracks and surface irregularities shall be completely filled. In warm dry weather the surface, immediately ahead of the spreading, shall be slightly damped by mist water sprayed applied mechanically, or for hand laying by a hand operated pressure sprayer, unless otherwise approved by the engineer.

**500.16.4.6 Rolling** -The need for rolling shall be as instructed by the engineer. Where rolling is required, a pneumatic-tyred rolrier having an individual wheel load between 0.75 and 1.5 tonnes shall be used, or as may be directed by the engineer. Rolling shall commence as soon as the slurry has set sufficiently to ensure that rutting or excessive movement will not occur.

#### **500.16.5 Opening to traffic**

Masking shall be removed after the slurry seal has been applied, without damage to the edge of the surfacing, and before opening the road or footway to traffic.

The contractor shall remove surplus aggregate from the treated areas using a method agreed by the engineer. The contractor shall monitor the slurry seal closely for a minimum period of 2 hours and if necessary the lane shall be swept again. The monitoring shall continue until the slurry seal has reached sufficient stability to carry unrestricted traffic. If there are signs of distress, the engineer shall require the contractor to reinstate traffic safety and management procedures or other such remedial action where necessary in order to prevent further damage.

Further operations to remove subsequently loosed aggregate shall be carried out over the next 48 hours. The areas treated and adjacent side roads, footways and paved areas shall be kept substantially free of loose aggregate for a period of 30 days after completion of the work.

#### **500.16.6 Surface finish and quality control of work.**

Generally, the surface finish of the completed construction shall conform to the requirements in section 900. For control of the quality of materials supplied and the works carried out, the relevant provisions of section 900 shall apply.

In addition, the finished slurry shall have a uniform surface texture throughout the work, without variations, of texture within the lane width, or from lane to lane, due to segregation of aggregates, or due to variations in the emulsion/water content of the mixture.

The finished surface shall be free from blow holes and surface irregularities in excess of 3 mm beneath a 1 metre straight edge due to scrapping, scabbing, dragging, droppings, excess overlapping or badly aligned longitudinal or transverse joints, damage by rain or frost, or other defects which remain 24 hours after laying.

**500.16.7 Arrangements for traffic** - During the period of construction, arrangements for traffic shall be made in accordance with the provisions of clause 100.12.

**500.16.8 Measurement for payment** - Slurry seal shall be measured as finished work as specified, in square metres.

**500.16.9 Rate** - The contract unit rate of slurry seal shall be payment in full for carrying out the required operations including full compensation for all components listed clause 500.1.8.8.2(i) to (xi).

### **500.17. SPECIFICATIONS FOR RECYCLING OF BITUMINOUS PAVEMENT (U.V- November 2000)**

**500.17.1 Scope** - This clause of the specifications covers the recycling of existing bituminous pavement materials to upgrade an existing bituminous pavement, which has served its first intended purpose. The work shall be performed on such widths and lengths as may be directed by the engineer and may consist of pavement removal, stockpiling of materials from the old pavement, addition of new bitumen and untreated aggregated in the requisite proportions, mixing, spreading and compaction of the blended materials.

Recycling processes can be categorised into in-situ recycling (where processing takes place on site), and central plant recycling (where reclaimed material is processed off site). The processes can be further sub-divided into hot and cold processes. This specification covers the hot process only. However, reclaimed aggregate from cold in-situ recycling can be used in the bituminous cold mix process specified in clause 500.19 subject to the resultant mixes achieving the specified standards.

#### **500.17.2 Reclaimed bituminous materials for central plant recycling**

**500.17.2.1 Proportion of reclaimed materials less than 10 percent** - If not more than 10% of reclaimed bituminous material is to be used in the production of bituminous macadam or dense graded bituminous base or binder course material, then clause 500.17.2.2 to 500.17.2.9 do not apply. However,

a) all reclaimed bituminous material shall be pre-treated before use such that the material is homogeneously mixed and the maximum particle size of reclaimed material does not exceed 40 mm.



b) the mixed material shall comply with the requirements of clauses 500.4 or 500.7 as appropriate.

**500.17.2.2 Proportions of reclaimed materials greater than 10 percent** - Reclaimed bituminous material of an amount greater than 10 percent, may be used in the production of bituminous macadam and dense graded bituminous base and binder course material, subject to the requirements of clauses 500.17.2.3 to 500.17.2.9 and subject to the satisfactory completion of full trial investigations in respect of all related materials, layer thickness, machine operations and finished works on a case-by-case basis entirely at the contractors cost and subject to the approval of the engineer. for estimating purposes, a maximum amount not greater than 30 per cent reclaimed bituminous material should be assumed.

**500.17.2.3 Materials for recycled pavement** - The recycled materials shall be a blend of reclaimed and new materials proportioned to achieve materials shall be tested and evaluated to find the optimum blend meeting the mixture requirements. Such testing and evaluation shall be carried out on representative samples, either core sampled from the carriageway or samples taken from stockpiles in accordance with current practice. The sampling frequency should be sufficient to determine how consistent the reclaimed material is and to provide representative samples for composition analysis and measurement of properties of recovered binder. As an absolute minimum, one sample to represent 500m of lane carriageway shall be taken.

**500.17.2.4 Bitumen extraction** - The procedure described in ASTM D-2172 shall be used to quantitatively separate aggregate and bitumen from any representative sample of reclaimed bituminous pavement.

**500.17.2.5 Aggregate evaluation** - Mechanical sieve analysis (IS:2386, Part 1, wet sieving method) shall be performed on the aggregate portion of the reclaimed bituminous pavement sample to determine the grading. It is essential that the reclaimed materials to be recycled are consistent, as variable materials will cause problems with the control of quality and impede the efficiency of the recycling operation. Suitable sources of consistent material of sufficient quantity for the scheme being considered need to be identified either in existing pavements, from stockpiles planning's of known origin or from another suitable source, before a decision can be made on the optimum percentage of reclaimed material.

After selecting the proportion of reclaimed materials to be recycled, the grading of the mixture may need adjustment, to meet specification requirements, by the addition of selected aggregate sizes.

**500.17.2.6 Evaluation of bitumen** - When the amount of reclaimed bituminous materials to be used in the mixture exceeds 10%, the penetration value of the recovered binder from the reclaimed bituminous material, before mixing, shall exceed 15 pen, after recovery of binder in accordance with the requirements of BS2000: Part397, when tested in accordance with IS: 1203. Provided the above requirement is met, hardening of the old binder, during the original mixing process or through ageing, can be compensated for by adding a softer bitumen, to obtain the appropriate final grade of binder.

The determination of the type and amount of binder required to be added in the final mix is essentially a trial and error procedure.

After mixing with recycled materials, the binder recovered from the mixture shall have a recovered penetration value not less than the value specified in Table 500-34.

Table 500-34. Minimum recovered binder penetration of recycled mixture

Specified Grade of Binder (Penetration)	Minimum Recovered Penetration Value of Binder after Mixing
45	27
65	39
90	54

**500.17.2.7 Rejuvenators** - The use of rejuvenators, and a test to measure their effectiveness, is described in clause 500.17.6.3.

**500.17.2.8 Untreated aggregate** - If necessary, fresh untreated aggregate shall be added to the reclaimed bituminous pavement to produce a mix with the desired grading. The aggregate shall be checked for quality requirements in accordance with Table 500-3 or Table 500-8 as appropriate. Reclaimed aggregate, if any, or any aggregate normally used for the desired bituminous mixture, or both, may be used for this purpose.

**500.17.2.9 Combined aggregate grading** - The blend of reclaimed and new aggregate shall meet the grading criteria specified in the relevant parts of clause 500.4 or 500.7, as appropriate and as approved by the engineer. The blend of aggregates shall be checked for resistance to stripping as specified in Tables 500-3 or 500-8 as appropriate.

**500.17.3 Mixture design** - The combined aggregate grading and binder content shall comply with the relevant tables in clauses 500.4 or 500.7. For dense graded bituminous mixtures the mixture design shall also comply with the requirements of Table 500-11.

**500.17.4 Reclaiming old pavement materials** - The removal of pavement materials to the required depth shall be accomplished either at ambient temperature (cold process) or at an elevated temperature (hot process), as approved by the engineer.

**500.17.4.1 Cold removal process** - In the cold process, the ripping and crushing operations shall be carried out using scarifiers, grid rollers, or rippers or by any other means as directed by the engineer. The removed materials shall be loaded and hauled for crushing to the required size as directed by the engineer. Alternatively, cold milling or planing machines can be used to reclaim bituminous pavement to controlled depths. After the bituminous layers are removed, any remaining aggregate materials that are to be incorporated in the recycled hot mixture shall be scarified and removed. When the pavement material removal is completed, any drainage deficiencies shall be corrected. After that, the base/sub-base as the case may be shall be cut, graded and compacted to the required profile and density.

**500.17.4.2 Hot removal process** - In this process, the road surface shall be heated, by any suitable means approved by the engineer, before scarification. A self-propelled plant shall be used, and a milling drum that follows the planer removes the heated soft bituminous layer. The depth, width and speed of travel shall be adjusted to suit specific requirements as directed by the engineer. During the heating process, the surface temperature of the road shall not exceed 200°C for more than 5 minutes.

**500.17.4.3 Stockpiling** - In the cold process, the reclaimed bituminous pavement material shall be stockpiles not exceeding 3m. The reclaimed untreated aggregate base/sub-base material shall be stockpiled in the same manner as new aggregate. The number and location of stockpiles shall be carefully planned for efficient operation of the hot-mix plant.

**500.17.5 Mixing and laying** - Generally, the requirements of clauses 500.4.3 or 500.7.4 as appropriate shall apply.

**500.17.6 In situ recycling- The remix and repave processes** - These processes are suitable for the production of bituminous concrete wearing course in accordance with the provisions of clause 500.9.

**500.17.6.1 Scope** - In the process of repaving, the existing surface is preheated and scarified but the scarified material is not removed. A layer of fresh bituminous mix material prepared in the integrated mixing unit of the plant is then spread evenly on the scarified surface to give a uniform profile. The spread material should be compacted as soon as possible after laying. In the process the total thickness of the pavement is increased by up to 50 mm. In the remix process, the scarified material should be taken from the mixing unit of the plant where it is recycled with fresh binder, aggregate and recycling agent. Then the recycled mixture is spread on the preheated surface and tamped and compacted to the required profile.

**500.17.6.2 Heating and scarifying** - Surfaces to be treated shall be heated by plant with surfaces insulated and fully enclosed. The heated width of surfacing shall exceed the scarified width by at least 75 mm on each side, except against the edge of the carriageway or kerb face. When new surfacing material is spilled onto the road surface it shall be removed before the existing surface is heated and scarified. Areas of unscarified material shall not exceed 50 mm x 50 mm

The depth of scarification shall be such that the bottom of the scarified layer is parallel to and below the finished road surface level by the thickness of wearing course material specified. A tolerance of  $\pm 6$  mm is permissible.

Where street furniture and other obstructions occur, these shall be suitably protected or removed and the void covered. Surface dressing and large areas of road markings shall be removed by milling, planning, scarifying or by similar approved processes.

The heated surface shall be evenly scarified to comply with the requirements of this clause. When street furniture is left in place or raised, the adjacent areas shall be scarified by other means, with the material either left in place or removed, prior to passage of the machine. If furniture needs to be repositioned on completion of work, the new wearing course material shall be used to make good the road surface for a maximum width of 200 mm around the obstruction.

During the reheating process the surface temperature of the road shall not exceed 200°C for more than 5 minutes.

**500.17.6.3 Rejuvenator** - For Remix, when required, rejuvenator shall be uniformly sprayed across the full-width of the processed material. The machine shall incorporate a meter for continuous verification of quantities, which shall be within  $\pm 5\%$  of the specified rate. The volume of rejuvenator shall vary in relation to the operating speed of the machine, which shall be related to the volume of material mixed or scarified.

The rejuvenator shall be a non-emulsified aromatic extract. Its properties shall be verified using the Rolling Thin Film Oven Test.

Rejuvenation of the existing pavement may also be performed by adding new hot-mix bituminous material containing a soft binder of suitable penetration for restoring the binder in the existing pavement to the required penetration.

**500.17.6.4 Mixing** - When required new hot-mix material shall be mixed with the heated and scarified road pavement material in a pugmill within the Remix machine, observing the mixing temperatures specified in Table 500-5.

After mixing, the recycled bituminous materials shall be automatically fed to a finishing unit, which spreads and levels the mixture to the specified thickness and cross-section. The new bituminous concrete wearing course shall be material complying with clause 500.9.

**500.17.6.5 Additional material (general)** - The proportion of new hot-mix bituminous material, and the proportion of existing bituminous pavement material shall be as directed by the engineer, together with the amount the road surface level is to be raised (if any).

The type and quantity of the new hot-mix material shall be determined by using the Marshall Mix Design procedure specified in the Asphalt Institute Manual MS-2, before work commences. Remix designs shall incorporate the stated proportion of material sampled from the existing road surface.

When additional coarse or fine aggregate or filler are required to be added, they shall comply with the requirements of clause 500.9.2. The amount of additional coarse or fine aggregate or filler to be added to the existing bituminous pavement material shall be notified to the engineer.

**500.17.6.6 Additional aggregate (Remix process)** - The coarse aggregate, fine aggregate and filler added to the Remixed material shall comply with the requirements of clause 500.9.2.

**500.17.6.7 New surfacing (Repave and Remix/repave processes)** - New surfacing material shall be bituminous concrete wearing course complying with clause 500.9, or other wearing course material approved by the engineer.

The new surfacing material shall be laid on, and compacted with, the reprofiled surfacing, which shall be at a temperature within the range of 100°C to 150°C.

**500.17.6.8 Binder** - The binder shall be recovered from samples taken from each layer of material laid. The method of recovery shall be in accordance with BS200:Part 397 or an equivalent test. The penetration of the binder shall be in the range 35-70 pen.

**500.17.6.9 Mixture design** - The surfacing material shall be sampled from the paver hopper or augers. Care shall be taken that only the material forming the new surface layer is sampled. The sample shall be reduced on site by rifling or quartering to approximately 5 kg and placed loose in an air-tight container.

The sample shall only be reheated once whilst within the container. As soon as the sample reaches the required temperature, the reheated material shall be remixed and three Marshall test specimens prepared in accordance with the procedures specified in MS-2.

The bulk density of each specimen shall be measured before Marshall Stability Testing. The mean stability and flow of the three specimens, measured in accordance with the procedures specified in MS-2, shall comply with the requirements of Table 500-19.

Finally the 3 Marshall specimens shall be combined and the maximum theoretical specific gravity ( $G_{mm}$ ) of the mixture is determined in accordance with ASTM D 2041. This maximum theoretical specific gravity ( $G_{mm}$ ) corresponds to 0% air voids in the mixture. the actual bulk specific gravity of a Marshall specimen determined in the Laboratory ( $G_{mb}$ ) will naturally be less than  $G_{mm}$ . The percent air voids ( $P_a$ ) in the specimen of the compacted mixture given by

$$P_a = \frac{G_{mm} - G_{mb}}{G_{mm} - G_{mb}} \times 100$$

$G_{mm}$

Should meet the requirements of air voids laid down in Table 500-19.

**500.17.7 Opening to traffic** - For recycled material forming the base or binder course layer, clause 500.4.5 or 500.7.5 shall apply as appropriate. For recycled material forming the wearing course layer, clause 500.9.5 shall apply.

**500.17.8 surface finish and quality control** - The surface finish of the completed construction shall conform to the requirements of clause 900.2.  
for control of the quality of materials supplied and the works carried out the relevant provisions of section 900 shall apply.

**500.17. 9 Arrangements for traffic** - During the period of construction, arrangements for traffic shall be made in accordance with the provisions of clause 100.12.

**500.17.10 Measurement for payment** - The recycled pavement work shall be measured in cubic metres or tonnes of finished work as stated in the contract.

**500.17.11 Rate** - The contract unit rate for recycled pavement shall be payment in full for carrying out the required operations including full compensation for all items as clause 500.1.8.8.2 (i) to (xi).

#### **500.18. SPECIFICATIONS FOR FOG SPRAY (U.V-November 2000)**

**500.18.1 Scope** - Fog spray is a very light application of low viscosity bitumen emulsion for purposes of sealing cracks less than 3 mm wide or incipient fretting or disintegration in an existing bituminous surfacing, and to help reduce loosening of chips by traffic on newly finished surface dressing.

**500.18.2 Material** - The bitumen emulsion shall be as specified in the contract or as instructed by the engineer. The emulsion shall be  
SS-1h (SS-1 can be used if the former is not available) complying with the requirements of ASTM D-977, or;  
CSS – 1h (CSS-1 can be used if the former is not available) complying with the requirements of ASTM D – 2397.

Before use these emulsions shall be diluted, 1 part emulsion to 1 part water. Alternatively, class A1-40 or K1-40 emulsions complying with the requirements of BS434:Part 1 : 1984 may be used. These emulsions have a lower viscosity than the above ASTM grades. They are rapid setting and they do not require to be diluted. Because of their low viscosity they should be used as soon as possible after delivery. If this is not possible, the drums should be very thoroughly rolled before use.

**500.18.3 Weather and seasonal limitations** - Spraying shall not take place when the temperature is below 10<sup>0</sup>C, nor in windy or dusty conditions, nor when it is raining or the surface to be sprayed is wet (a damp surface is acceptable but refer to clause 500.18.4.2).

#### **500.18.4 Construction operations**

**500.18.4.1 Equipment** - The fog spray shall be applied by means of a self-propelled or towed bitumen pressure sprayer. The spray bar should be protected from gusts of wind by means of a hood.

**500.18.4.2 Preparation of surface** - The surface on which the fog spray is to be applied shall be thoroughly cleaned with compressed air, scrubbers etc. the cracks shall be cleaned with a pressure air jet to remove all dirt, dust etc.

**500.18.4.3 Application** - The fog seal shall be applied at a rate of 0.5-1.0 litres/m<sup>2</sup>, using equipment such as pressure tank, flexible hose and spray bar or lance.

**500.18.4 Blinding** - If specified in the contract or ordered by the engineer, the fog spray shall be blinded with graded grit of 3mm size and under, coated with about 2 percent of the emulsion by weight. The pre coated grit shall be allowed to be cured for at least one week or until they become non-sticky and can be spread easily.

**500.18.6 Quality control of work** - For control of the quality of materials supplied and the works carried out, the relevant provisions of section 900 shall apply.

**500.18.7 Arrangements for traffic** - During the spraying operations, arrangements for traffic shall be made in accordance with the provisions of clause 100.12. The surface should not be opened to traffic for 24 hours after spraying. If pick-up does occur a light blinding of crusher dust or sand should be applied.

**500.18.8 Measurement for payment** - Fog spray and blinding (if used) shall be measured in terms of surface area of application, for the area covered, in square metres.

**500.18.9 Rate** - The contract unit rate for fog spray and blinding (if used) shall be payment in full for carrying out the required operations including full compensation for all components listed in clause 500.1.8.8.2 (i) to (xi) as applicable to the work specified in these specifications.

#### **500.19. SPECIFICATIONS FOR BITUMINOUS COLD MIX (INCLUDING GRAVEL EMULSION) - (U.V-November 2000)**

**500.19.1 The design mix** - Bituminous Cold Mix consists of a mixture of unheated mineral aggregate and emulsified or cutback bitumen. This specification deals only with plant mix (as opposed to mixed-in-place). Two types of mix are considered, namely Designed Cold Mix and Recipe Cold Mix. The Design Mix procedure shall be used unless the Recipe Mix procedure is specifically approved by the engineer.

**500.19.2 Designed cold mix** - This specification is based on The Asphalt Institute Manual MS-14, which contains additional information for guidance. These mixes are considered suitable for use as base course, appropriate to their stability, in new work or major repair work.

##### **500.19.2.1 Materials**

**500.19.2.1.1 Binder** - The binder shall be a bituminous emulsion as specified in AASHTO M 140 (ASTM D977) OR AASHTO M 208 (ASTM D2397), namely MS-2, MS-2h, HFMS-2s, SS-1, SS-1h, CMS-2h, CSS-1 and CSS-1h. Alternatively a cutback bitumen as specified in AASHTO M 82 (ASTM D2027) or ASTM D2026, namely MC 70, 250, 800 & 3000 and SC250, 800 and 3000 may be used, or, if approved by the engineer, an equivalent material which conforms with IS:8887 and IS:217.

A general guides for the use of these binders is given in Table 500-35. However the final selection shall be made only after laboratory evaluation with the aggregates to be used. The binder with the highest residual viscosity at ambient temperatures that can reasonably be handled by the mixing and laying equipment proposed shall be used.

Table 500 – 35. Uses of bitumen in cold mix

Type of construction	Emulsified bitumen		Cutback bitumen	
	Anionic	Cationic	Medium curing (MC)	Slow Curing (SC)
Cold-laid plant mix pavement base and surfaces	MS-2, HFMS-2 MS-2h, HFMS-2h HFMS-2s SS-1 SS-1h	CMS-2 CMS-2h CSS-1 CSS-1h	70 250 800 3000	250 800 300
Open graded aggregate well-graded aggregate patching, immediate use patching, stockpile	* * * * * * * * *	* * * * * * * *	* * * * * * *	* * * * * *

**500.19.2.1.2 Aggregates** - The aggregates shall comply with the requirements of clause 500.4.2.2 and 500.4.2.3. If the aggregates are not properly coated with anionic emulsion or cutback bitumen, a small amount of hydrated lime, an approved antistripping agent (see Appendix 5) or a change to cationic emulsion shall be proposed by the contractor, for the approval of the engineer.

**500.19.2.1.3 Aggregate grading and binder content** - The combined aggregate grading for the particular mixture, when tested in accordance with IS:2386 Part 1, (wet sieving method), shall fall within the limits shown in Table 500-36.

#### 500.19.2.2 Mixture design

**500.19.2.2.1 Requirements for the mixture** - Apart from conformity with the grading and quality requirements for individual ingredients, the mixture shall meet the requirements set out in Table 500-37.

**500.19.2.2.2 Binder content** - The binder content shall be optimised to achieve the requirements of the mixture set out in Table 500-41. The method adopted shall be that described in Appendix F and H of Asphalt Institute's Manual, MS-14.

Table 500-36. Aggregate grading and bitumen content

Nominal maximum size (mm)	9.5	13.2	19.0	26.5
Allowable thickness (mm)	25 – 35	36 – 50	51 – 75	76 - 100
IS Sieve (mm)	Cumulative % by weight of total aggregate passing			
37.5	-	-	-	100
26.5	-	-	100	90 – 100
19.0	-	100	90 – 100	-
13.2	100	90 - 100	-	56 – 80
9.5	90 - 100	-	60 – 80	-
4.75	60 - 80	45 – 70	35 – 65	29 – 59
2.36	35 - 65	25 – 55	20 – 50	19 – 45
0.30	6 - 25	5 – 20	3 – 20	5 – 17
0.075	2 - 10	2 - 9	2 - 8	1 - 7
1. Guide to binder content, % by weight of total mixture				
Cutback	Min 4 to Max 6			
Emulsion	Min 7 to Max 10			

Table 500 – 37. Mixture requirements for designed cold mix

Parameter	Emulsion <sup>1</sup>	Cutback <sup>2</sup>
Minimum Stability (kN at 22.2°C) Emulsion (kN at 25°C) Cutback	2.2 for paving	2.2 for maintenance 3.3 for paving
Percent maximum stability loss on soaking	50 <sup>3</sup>	25 <sup>4</sup>
Minimum flow (mm)	2	2
Compaction level (number of blows)	50	75
Per cent air voids	3 - 5 <sup>5</sup>	3 - 5
Percent voids in mineral aggregate (VMA)	See Table 500 - 38	
Percent minimum coating <sup>6</sup>	50	-

Notes :

1. Using "Marshall method for emulsified asphalt – aggregate cold mixture design".
2. Using "Marshall method for cut-back asphalt-aggregate cold mixture design", Appendix H, MS-14.
3. With vacuum saturation and immersion.
4. Four days soak at 25°C
5. Refers to total voids in the mix occupied by air and water.
6. Coating Test, Appendix F, MS-14.

**500.19.2.2.3 Job mix formula** - The contractor shall inform the engineer in writing, at least one month before the start of the work, the job mix formula proposed for use in the works and shall give the following details:

- (i) Source and location of all materials;
- (ii) Proportions of all materials expressed as follows where each is applicable;
  - (a) Binder, as percentage by weight of total mixture;
  - (b) Coarse aggregate/fine aggregate as percentage by weight of total aggregate;
- (iii) A single definite percentage passing each sieve for the mixed aggregate;
- (iv) The results of tests enumerated in Table 500-39 as obtained by the contractor.
- (v) Spraying temperature of binder if appropriate.

While working out the job mix formula, the contractor shall ensure that it is based on a correct and truly representative sample of the materials that will actually be used in the work and that the mixture and its different ingredients satisfy the physical and strength requirements of these specifications.

Approval of the job mix formula shall be based on independent testing by the engineer for whom samples selected jointly with the engineer of all ingredients of the mix shall be furnished by the contractor as requisite by the former.

The approved job mix formula shall remain effective unless and until modified by the engineer. Should a change in the source of materials be proposed, a new job mix formula shall be established and approved by the engineer before actually using the materials.

Table 500.38. Minimum per cent voids in mineral aggregate (VMA)

Nominal Maximum Particle Size IS Sieve (mm)	Minimum VMA (percent)
9.5	16.0
12.5	15.0
19.0	14.0
25.0	13.0
37.5	12.0



**500.19.2.2.4 Permissible variation from the job mix formula** - It shall be the responsibility of the contractor to produce a uniform mix conforming to the approved job mix formula, subject to the permissible variations of the individual percentages of the various ingredients in the actual mix from the job mix formula to be used, within the limits as specified in Table 500-39. These variations are intended to apply to individual specimens taken for quality control tests in accordance with section 900.

### **500.19.2.3 Construction operations**

**500.19.2.3.1 Weather and seasonal limitations** - Construction with cold mix must not be undertaken when ambient temperature below 10°C are expected, during rain, in standing water, or generally when poor weather is predicted. Bitumen emulsions and cutbacks depend on the evaporation of water and/or solvent for the development of their curing and adhesion characteristics. Cold weather, rain and high humidity slow down the rate of curing. Extra manipulation may be required to remove volatiles in cool and humid conditions. Wind increases the rate of evaporation.

Table 500-39. Permissible variations from the job mix formula

Description	Permissible variation	
	Base/ binder course	Wearing course
Aggregate passing 19 mm sieve or larger	± 8%	± 7%
Aggregate passing 13.2 mm, 9.5 mm	± 7%	± 6%
Aggregate passing 4.75 mm	± 6%	± 5%
Aggregate passing 2.36 mm, 1.18 mm, 0.6 mm	± 5%	± 4%
Aggregate passing 0.3 mm, 0.15 mm	± 4%	± 3%
Aggregate passing 0.075 mm	± 2%	± 1.5%
Binder content	± 0.3%	± 0.3%

**500.19.2.3.2 Preparation of the base** - The base on which cold mix is to be laid shall be prepared, shaped and leveled to the required profile in accordance with clauses 500.1 And 900.2 as appropriate, and a prime coat, where specified, shall be applied in accordance with clause 500.2 or as directed by the engineer.

**500.19.2.3.3 Tack coat** - A tack coat in accordance with clause 500.3 shall be applied over the base on which the cold mix is to be laid where specified in the contract.

**500.19.2.3.4 Preparation and transportation of the mixture** - Mixing can be carried out using one of the following types of mixer, which is provided with equipment for spraying the binder at a controlled rate and, if necessary, for heating the binder to a temperature at which it can be applied uniformly to the aggregate:

- (a) rotary drum type concrete mixer;
- (b) single or twin shaft concrete or macadam mixer;
- (c) batch or continuous type mixer without dryer or screens other than a scalping screen.

A sufficient number of haul trucks with smooth, clean beds should be available to ensure continuous operation of the mixing plant. The type of truck used for transporting the mixture from the mixer to the road site must be suited to the contractor's nominated laying procedure methodology.

**500.19.2.3.5 Spreading** - Designed cold mix shall be placed only when the specified density can be obtained. The mixture shall not be placed on any wet surface or when weather conditions will otherwise prevent its proper handling or finishing.

If spreading by motor grader, the grader must have a blade that is straight and sharp and long enough to ensure finishing to close, straight, transverse tolerances and all joints and linkages must be in good condition. The grader must be heavy enough to hold the blade firmly and uniformly on the surface while spreading the mixture.

If climatic conditions and aggregate grading permit evaporation of moisture or volatiles without aeration by manipulation, a conventional self-propelled asphalt paver shall be used to place designed cold mix.

**500.19.2.3.6 Compaction** - Initial compaction of the laid material shall be carried out using a pneumatic –tyred roller of a weight appropriate to the layer thickness to be compacted with single layer thickness being 25-100 mm and all compaction being in accordance with clause 500.1.6 and clause 500.1.7. Smooth tyres shall be used. Final rolling and smoothing of the surface should be completed using steel wheel rollers. The contractor shall demonstrate at laying trials that his proposed laying and compaction methods can achieve a satisfactory result.

**500.19.2.4 Opening to traffic** - Traffic shall not be allowed to run on new work until all the water or volatiles in the mixture have evaporated, as determined by the engineer. The rate of evaporation will be influenced by the temperature, humidity and wind conditions.

**500.19.2.5 surface finish and quality control of work** - The surface finish of construction shall conform to the requirements in section 900. For control of the quality of supplied materials and the works carried out, the relevant provisions of section 900 shall apply.

**500.19.2.6 Arrangements for traffic** - During the period of construction, arrangements for traffic shall be made in accordance with the provisions in section 100.

**500.19.Measurement for payment** - Designed cold mix shall be measured as finished work, for the area covered, in cubic metres, by weight in metric tonnes, or by square metres at a specified thickness as specified in the contract.

**500.19.2.8 Rate** - The contract unit rate for designed cold mix shall be payment in full for carrying out the required operations including full compensation for all components listed in clause 500.1.8.8.2 (I) to (xi). The rate shall cover the provision of the specified grade of cutback in the mix at 5 per cent of the weight of the total mix or emulsion at 8 per cent of the weight of the total mix, with the provision that the variation of quantity of binder will be assessed on the basis of the amount agreed by the engineer and the payment adjusted as per the rate for cutback or emulsion quoted in the Bill of Quantities.

### **500.19.3 SPECIFICATIONS FOR RECIPE COLD MIX (U.V-November 2000)**

**500.19.3 Recipe cold mix** - This specification is based on BS 434 :Part 2:1984 which contains additional information. These are premixes made with emulsion binder which are laid immediately after mixing and while the emulsion is still substantially in an unbroken state. These mixes are considered suitable for use only for emergency and minor repair work and temporary road surface improvement.

#### **500.19.3.1 Materials**

**500.19.3.1.1 Binder** - Emulsions of sufficient stability for mixing with the particular graded aggregate should be used. Grades of emulsion quoted are in accordance with BS434 : Part1 : 1984 but comparable grades to IS or AASHTO specifications may be used. Guidance on selection of an appropriate grade of emulsion is given in the Manual for Construction and Supervision of Bituminous Works. The corresponding grades in IS:8887 are only broadly classified as RS, MS and SS and further sub classification is not available at present.

**500.19.3.1.2 Aggregates** - Any normal, clean, but not necessarily dry, aggregate can be used, provided that it has a sufficiently high crushing strength with regard to the traffic to be carried. Typical gradings are given in Table 500-40.

**500.19.3.1.3 Aggregate grading and binder content** - When tested in accordance with IS:2336 part 1 (wet sieving method) the combined aggregate grading for the particular mixture shall fall within the limits shown in Table 500-40. The grade and range of quantity of emulsion are also indicated in this table. The engineer shall approve the actual quantity of emulsion to be used after seeing the results of trial mixers made in the laboratory.

Table 500-40. Composition of recipe mixes

Nominal Size (mm) and type of macadam	40 single course	40 open textured base course	14 open textured wearing course	6 medium textured wearing course	- Fine coated
Allowable Thickness (mm)	75 – 100	75 – 100	31 – 50	21 – 30	15 - 20
IS Sieve Size mm	Cumulative % by weight of total aggregate passing				
45	100	100	-	-	-
37.5	90 – 100	90 – 100	-	-	-
26.5	55 – 90	55 - 85	-	-	-
19	-	-	100	-	-
13.2	35 – 55	15 - 35	90 – 100	-	-
9.5	-	-	55 - 75	100	-
6.3	20 – 30	-	25 - 45	90 – 100	100
3.35	10 – 20	0 - 10	15 - 25	45 - 65	-
2.36	-	-	-	-	75 - 100
1.18	-	-	-	10 - 30	-
0.60	-	-	-	-	30 - 55
0.30	2 – 10	-	--	-	-
0.15	-	-	-	-	10 - 25
0.075	-	-	2 – 6	2 – 8	5 – 15
Emulsion grade and quantity					
Generally	A2 – 57 <sup>(4)</sup> or A2 – 50 <sup>(4)</sup>				
Under some Circumstances	-	-	-	A3	A3
Quantity <sup>(1)</sup> Litres/tonne	55 to 70	45 TO 65	70 to 90	85 to 100	100 to <sup>(2) (3)</sup> 120

Note:

1. For pricing purposes the lower quantity in these ranges should be assumed.
2. With coarser grading quantity may sometimes be reduced to 80 litres/tonne and with finer grading it may sometimes be increased up to 135 litres/tonne.
3. Use 0 - 70 litres/tonne of water as necessary.
4. A2 – 50 and A2 – 57 are British grades of emulsion and their grading system is explained in the Manual

### **500.19.3.2 Construction operations**

**500.19.3.2.1 Weather and seasonal limitations** - Construction with cold mix must not undertaken when ambient temperatures below 10°C are expected or generally when poor weather is predicted. Bitumen emulsion and cutbacks depend on the evaporation of water and/or solvent for the development of their curing and adhesive characteristics. Cold weather, rain, and high humidity slow down the rate of curing. Extra manipulation may be required to remove volatile in cool or humid conditions. Wind increases the rate of evaporation

**500.19.3.2.2 Preparation of base** - The base on which the cold mix is to be laid shall be prepared shaped and graded to the required profile in accordance with clauses 500.1 and 900.2 as appropriate, and a prime coat if specified in the contract, or required by the engineer, shall be applied in accordance with clause 500.2, or as directed by the engineer.

**500.19.3.2.3 Tack coat** - A tack coat in accordance with clause 500.3 shall be applied over the base on which the cold mix is to be laid if specified in the contract or required by the engineer.

**500.19.3.2.4 Preparation and transportation of the mixture** - Mixing shall be carried out using one of the following types of mixer, which is provided with equipment for spraying the binder at a controlled rate, and, if necessary, for heating the binder to a temperature at which it can be applied uniformly to the aggregate.

- (a) rotary drum type concrete mixer;
- (b) single or twin shaft concrete or macadam mixer;
- (c) batch or continuous type mixer without dryer or screens other than a scalping screen.

A sufficient number of haul trucks with smooth, clean beds should be available to ensure continuous operation of the mixing plant. The type of truck used for transporting the mixture from the mixer to the road site must be suited to the chosen laying procedure.

**500.19.3.2.5 Spreading** - The mixed material should be spread immediately after preparation. The mixture shall be placed only when the specified density can be obtained. The mixture shall not be placed on any wet surface or when weather conditions will otherwise prevent its proper handling or finishing.

If spreading by motor grader, the grader must have a blade that is straight and sharp and long enough to ensure finishing to close straight transverse tolerances and all joints and linkages must be in good condition. The grader must be heavy enough to hold the blade firmly and uniformly on the surface while spreading the mixture. On surface courses, the tyres must be smooth.

The methodology for spreading shall be approved by the engineer prior to laying, and if required a laying trial conducted to prove the laying method satisfactory before approval.

**500.19.3.2.6 Compaction** - Initial compaction of the laid material shall be carried out using a pneumatic tyred roller of a weight appropriate to the layer thickness to be compacted with single layer thicknesses being 25-100 mm and all compaction being in accordance with clause 500.1.6 and 500.1.7. Smooth tyres shall be used. Final rolling and smoothing of the surface should be completed using steel wheel rollers. The contractor shall demonstrate at laying trials that his proposed laying and compaction methods can achieve a satisfactory result.

**500.19.3.3 Opening to traffic** - Traffic shall not be allowed to run on new work until all the water or volatiles in the mixture have evaporated. The rate of evaporation will be influenced by the temperature, humidity and wind conditions.

**500.19.3.4 Surface finish and quality control of work** - The surface finish of construction shall conform to the requirements of clause 900.2. for control of the quality of materials supplied and the works carried out, the relevant provisions of section 900 shall apply.

**500.19.3.5 Arrangements for traffic** - During the period of construction, arrangements for traffic shall be made in accordance with the provisions of clause 100.12.

**500.19.3.6 Measurement for payment** - Recipe Cold Mix shall be measured as finished work, for the area instructed to be covered, in cubic metres, by weight in metric tonnes, or in square metres at a specified thickness, as specified in the contract.

**500.19.3.7 Rate** - The contract unit rate for Recipe Cold Mix shall be payment in full for carrying out the required operations including full compensation for all components listed in clause 500.1.8.8.2 (i) to (xi). The rate shall cover the provision of the specified grade of emulsion at the lower quantity in the range for each type of mix indicated in Table 500-44 with the provision that the variation of quantity of emulsion will be assessed on the basis of the amount agreed by the engineer and the payment adjusted as per the rate for emulsion quoted in the Bill of Quantities.

## **500.20. SPECIFICATIONS FOR SAND ASPHALT BASE COURSE (U.V-November 2000)**

**500.20.1 Scope** - This work shall consist of a base course composed of a mixture of sand, mineral filler where required and bituminous binder, placed and compacted upon a prepared and accepted subgrade in accordance with these specifications and the lines, levels, grades dimensions and cross sections shown on the drawings or as directed by the engineer.

Note – Sand Asphalt Base course is used in special situations like quality coarse aggregates not being available within economical leads and/or water needed for conventional base course not being readily available, as in desert areas.

### **500.20.2 Materials**

**500.20.2.1 Bitumen** - The bitumen shall be paving bitumen of penetration grade S65 (60/70) or S90 (80/100) as specified in the contract, both as per Indian Standard specifications for “Paving Bitumen” IS:73.

**500.20.2.2 Sand** - The sand shall be clean, naturally occurring or blended material free from any deleterious substances, dry and well graded within the limits given in Table 500-41 and with other physical properties conforming to the requirements of this table.

**500.20.2.3 filler** - When required, filler shall consist of finely divided mineral matter such as rock dust, hydrated lime or cement as approved by the engineer. The filler shall conform to clause 500.7.2.4.

### **500.20.3 Mix design**

**500.20.3.1 Requirements for the mixture** - Apart from conformity with the grading and quality requirements for individual ingredients, the mixture shall meet the requirements set out in Table 500-42.

Table 500-41. Sand grading and physical requirements

Sieve Size (mm)	Cumulative percentage by weight of total aggregate passing
9.5	100
4.75	85 - 100
2.36	80 - 100
1.18	70 - 98
0.60	55 - 95
0.30	30 - 75
0.15	10 - 40
0.075	4 - 10
Plasticity Index (%)	6 max.
Sand equivalent (IS: 2720, Part 37)	30 min.
Los Angeles Abrasion Value (IS: 2386, Part 4)	40 max.

Table 500-42. Requirements for sand asphalt base course

Parameter	requirement
Minimum stability (kN at 60°C)	2.0
Minimum flow (mm)	2
Compaction level (Number of blows)	2 x 75
Percent air voids	3 - 5
Percent voids in mineral aggregate (VMA)	> 16
Percent voids filled with bitumen (VFB)	65 - 75

**500.20.3.2 Binder content** - The binder content shall be optimised to achieve the requirements of the mixture set out in Table 500-46. The Marshall method for determining the optimum binder content shall be adopted as described in The Asphalt Institute Manual MS-2.

**500.20.3.3 Job mix formula** - The contractor shall develop the job mix formula proposed for use in the works and shall give the following details:

- (i) Source and location of all materials;
- (ii) Proportions of all materials expressed as follows where each is applicable:
  - (a) Binder, as percentage by weight of total mixture;
  - (b) Sand/Mineral filler as percentage by weight of total aggregate including mineral filler.
- (iii) A single definite percentage passing each sieve for the mixed aggregate;
- (iv) The results of tests enumerated in Table 500-46 as obtained by the contractor.
- (v) Test results of physical characteristics of aggregates to be used;
- (vi) Mixing temperature and compacting temperature.

While working out the job mix formula, the contractor shall ensure that it is based on a correct and truly representative sample of the materials that will actually be used in the work and that the mixture and its different ingredients satisfy the physical and strength requirements of these specifications.

Approval of the job mix formula shall be based on independent testing by the engineer for whom joint samples of all ingredients of the mix shall be furnished by the contractors as required by the former.

The approved job mix formula shall remain effective unless and until modified, by the engineer. Should a change in the source of materials be proposed, a new job mix formula shall be established and approved by the engineer before actually using the materials.

**500.20.3.4 Permissible variation from job mix formula** - The contractor shall produce a uniform mix conforming to the approved job mix formula, subject to the permissible variations of the Individual percentages of the various ingredients in the actual mix from the job mix formula to be used, within the limits as specified in Table 500-43. These variations are intended to apply to individual specimens taken for quality control tests as described in section 900.

#### **500.20.4 Construction operations**

**500.20.4.1 Weather and seasonal limitations** - Clause 500.1.5.1 shall apply.

**500.20.4.2 Preparation of base** - The surface on which Sand Asphalt base course material is to be laid shall be prepared, shaped and graded to the profile required for the particular layer in accordance with clauses 500.1 and 900.2 as appropriate or as directed by the engineer. The surface shall be thoroughly swept clean free from dust and foreign matter using a mechanical brush, and the dust blown off by the compressed air. In confined locations where mechanical plant cannot access, other methods shall be used as approved by the engineer. a prime coat, where specified, shall be applied in accordance with clause 500.2 or as directed by the engineer.

Table 500-43. Permissible variations from the job mix formula

Description	Permissible variation
Aggregate passing 4.75 mm	± 6%
Aggregate passing 2.36 mm, 1.18 mm, 0.6 mm	± 5%
Aggregate passing 0.3 mm, 0.15 mm	± 4%
Aggregate passing 0.075 mm	± 2%
Binder content	± 0.3%
Mixing temperature	± 10°C

**500.20.4.3 Tack coat** - A tack coat over the base shall be applied in accordance with clause 500.3, or otherwise as directed by the engineer.

**500.20.4.4 Preparation and transportation of the mixture** - The provisions of clauses 500.1.3 and 500.1.4 shall apply.

**500.20.4.5 spreading** - The provisions of clauses 500.1.5.2 to 500.1.5.4 shall apply. Mixing must be accomplished at the lowest temperature and in the shortest time that will produce a mixture with complete coating of the aggregate and at a suitable temperature to ensure proper compaction. The ideal mixing and compaction temperatures for the particular bitumen in use shall be obtained from the Bitumen Test Data Chart given in the Manual for Construction and Supervision of Bituminous works and shall correspond to a viscosity of 2 Poise (0.2 Pa.s) and 3 Poise (0.3 Pa.s) respectively, based on the original (unaged) bitumen properties. For guidance, the ranges of acceptable mixing and rolling temperatures for some typical penetration grade bitumen are shown in Table 500.5.

**500.20.4.6 Rolling** - Clause 500.1.6 shall apply. Generally the initial or breakdown rolling shall be done with 8-10 tonne deadweight smooth-wheeled rollers. The intermediate rolling shall be done with 8-10 tonne deadweight or vibratory rollers or with a pneumatic tyred roller of 12-15 tonne weight having a tyre pressure of at least 5.6 kg/sq.cm. The finish rolling shall

be done with 8-10 tonne deadweight smooth wheeled tandem rollers. The exact pattern of rolling shall be established at the laying trials.

**500.20.5 Opening to traffic** - Traffic may be allowed after completion of the final rolling when the temperature of the mixture at the mid-depth of the completed layer has cooled to the daytime maximum ambient temperature. When daytime maximum ambient temperatures are in excess of 35°C, great care is needed to ensure that this criterion is met particularly where slow moving heavy traffic is involved.

**500.20.6 surface finish and quality control of work** - The surface finish of the completed construction shall conform to the requirements of clause 900.2.

For control of the quality of materials supplied and the works carried out, the relevant provisions of section 900 shall apply.

**500.20.7 Arrangements for traffic** - During the period of construction, arrangement for traffic shall be made in accordance with the provisions of clause 100.12.

**500.20.8 measurement for payment** - Sand Asphalt Base course materials shall be measured as finished work, for the area covered, in cubic metres, metric tonnes, or in square metres at a specified thickness, as stated in the contract.

**500.20.9 Rate** - The contract unit rate for Sand Asphalt Basecourse materials shall be payment in full for carrying out the required operations including full compensation for all components listed in clause 500.1.8.8.2 (i) to (xi). The rate shall cover the provisions of 5 per cent of bitumen by weight of the total mixture.

The variation from the actual percentage of bitumen approved by the engineer and used will be assessed and the rate adjusted, plus or minus, using the rate for bitumen in the Bill of Quantities.

## **500.21. SPECIFICATIONS FOR MODIFIED BINDER (U.V-November 2000)**

**500.21.1 Scope** - Modified binders comprise a base binder, to which is added either natural rubber, crumb rubber or polymer such as Styrene-Butadiene-Styrene (SBS), Ethylene-Vinyl-Acetate (EVA) or Low Density Polyethylene (LDPE). The purpose is to achieve a high performance binder with improved properties, particularly at extremes of temperature.

### **500.21.2 Materials**

**500.21.2.1 Base binder** - The base binder into which the modifier is incorporated shall conform to IS:73. The choice of grade shall be such that it is compatible with the modifier and, when mixed shall have the properties described in clause 500.21.3.

**500.21.2.2 Modifier** - The modifier shall be a natural rubber, crumb rubber or any other polymer which is compatible with the base binder and which allows the properties given in clause 500.21.3 to be achieved. For further details IRC:SP:53-1999 may be referred to. The modifier, in the required quantity shall be blended at the refinery or at the site plant capable of producing modified binder.

**500.21.3 Modifier proportions** - The quantity of modifier to be added shall be determined by tests on the base binder and the modified binder and the properties desired. A reference may be made to the Manual for Construction and Supervision of Bituminous Works for indicative dosage of different types of modifiers. The properties of the modified binder shall be as given in Table 500-44, 500-45 or 500-46 according to the requirements of the contract.



**500.21.4 Mixing** - The modifier shall be blended with the base binder so that it disperses thoroughly prior to use. The type of mixing equipment used shall be suited to the modifier type.

#### **500.21.5 Quality control of materials**

**500.21.5.1 Binder properties** - For control of the quality of the base binder, the relevant provisions of section 900 shall apply. Additionally, the modified binder shall be tested for all the properties listed in Table 500-44, 500-45 or 500-46 as appropriate and certificates produced prior to use. During use, the requirements for softening point, penetration and elastic recovery shall be tested regularly. If the modified binder is produced on site then tests shall be carried out daily. If pre-blended modified binder is used tests shall be carried out weekly.

Table 500-44. Requirements of polymer modified binders (Elastometric thermoplastics and rubber latex)

Designation	Grade and Requirements			Method of Test
	PMB 120	PMB 70	PMB 40	
Penetration at 25°C, 0.1mm, 100g, 5 sec.	90 to 150	50 to 89	30 to 49	IS: 1203 – 1978
Penetration at 40°C, 0.1 mm, 200g, 60 sec, Minimum*	35	22	18	IS: 1205 – 1978
Softening Point, (R & B), °C, Minimum	38	48	59	IS: 1205 – 1978
Fraas Breaking Point, °C, Maximum*	-24	-16	-12	IS: 9381 – 1978
Ductility at 27°C, cm, Minimum	75	50	50	IS: 1208 – 1978
Flash Point, COC, °C, Minimum	220	220	220	IS: 1209 – 1978
Elastic Recovery of Half Thread in Ductilometer at 15°C, %, Minimum	70 (50)**	60 (40)**	50 (30)**	ASTM D 5976 – 1996
Separation, Difference in Softening Point, R&B, °C, Maximum	4	4	4	ASTM D5976 – 1996
Viscosity at 150°C, Poise	1-3	2-6	4-8	IS:1206 - 1978

Test on Thin Film Oven Test Residue, TFOT (IS: 9382 – 1979)

Designation	Grade and Requirements			Method of Test
	PMB 120	PMB 70	PMB 40	
Penetration at 4°C, 0.1mm, 200g, 60sec, Minimum*	18	15	12	IS:1203 – 1978
Loss in Weight, %, Maximum	1.0	1.0	1.0	IS: 9382 – 1979
Increase in Softening Point, °C, Maximum	7	6	5	IS:1205 – 1978
Reduction in Penetration at 25°C, %, Maximum	35	35	35	IS: 1203 – 1978
Elastic Recovery of Half Thread in Ductilometer at 15°C, %, Minimum	60 (35)**	40 (30)**	35 (25)**	ASTM D5976 - 1996

\* Relevant to snow bound cold climate areas

\*\* Natural Rubber Modified Bitumen

Table 500-45. Requirements of polymer modified binders (Plastomeric thermoplastics)

Designation	Grade and Requirements			Method of Test
	PMB 120	PMB 70	PMB 40	
Penetration at 25°C, 0.1mm, 100g, 5 sec.	90 to 150	50 to 89	30 to 49	IS: 1203 – 1978
Penetration at 40°C, 0.1 mm, 200g, 60 sec, Minimum*	35	22	18	IS: 1205 – 1978
Softening Point, (R & B), °C, Minimum	38	48	59	IS: 1205 – 1978
Fraas Breaking Point, °C, Maximum*	-20	-15	-10	IS: 9381 – 1978
Ductility at 27°C, cm, Minimum	50	40	30	IS: 1208 – 1978
Flash Point, COC, °C, Minimum	220	220	220	IS: 1209 – 1978
Elastic Recovery of Half Thread in Ductilometer at 15°C, %, Minimum	60	50	40	ASTM D 5976 – 1996
Separation, Difference in Softening Point, R&B, °C, Maximum	3	3	3	ASTM D5976 – 1996
Viscosity at 150°C, Poise	1-2	2-4	4-8	IS:1206 - 1978

Test on Thin Film Oven Test Residue, TFOT (IS: 9382 – 1979)

Designation	Grade and Requirements			Method of Test
	PMB 120	PMB 70	PMB 40	
Penetration at 4°C, 0.1mm, 200g, 60sec, Minimum*	18	15	12	IS:1203 – 1978
Loss in Weight, %, Maximum	1.0	1.0	1.0	IS: 9382 – 1979
Increase in Softening Point, °C, Maximum	7	6	5	IS:1205 – 1978
Reduction in Penetration at 25°C, %, Maximum	35	35	35	IS: 1203 – 1978
Elastic Recovery of Half Thread in Ductilometer at 15°C, %, Minimum	45	35	30	ASTM D5976 - 1996

\* Relevant to snow bound cold climate areas

Table 500-46. Requirements of polymer modified binders (Treated with modified crumb rubber)

Designation	Grade and Requirements			Method of Test
	PMB 120	PMB 70	PMB 40	
Penetration at 25°C, 0.1mm, 100g, 5 sec.	50 - 70	50 – 60	40 - 60	IS: 1203 – 1978
Softening Point, (R & B), °C, Minimum	50	55	60	IS: 1205 – 1978
Elastic Recovery of Half Thread in Ductilometer at 15°C, %, Minimum	40	35	30	ASTM D5976 - 1996

Test on Thin Film Oven Test Residue (IS: 9382 – 1979)

Reduction in Penetration at 25°C, %, Maximum	60	60	60	IS: 1203 - 1978
Increase in Softening Point, (R&B), °C, Maximum	5	5	5	IS: 1205 – 1978
Elastic Recovery of Residue of Half Thread in Ductilometer at 15°C, %, Minimum	25	20	15	ASTM D5976 - 1996

CRMB – Crumb Rubber Modified Bitumen

**500.21.5.2 Storage stability** - Pre-blended modified binders which are to be stored without circulation or agitation facility shall be tested for storage stability prior to use, in accordance with Appendix 1 of IRC:SP:53-1999. The mean of the differences in softening point, top to bottom, of not less than three pairs of samples shall not exceed 5°C.

Other pre-blended modified binders shall be stored with appropriate circulation or agitation facility, according to the manufacturer's instructions.

**500.21.6 Measurement for payment** - Modified binder supplied for the contract shall be paid for in Tonnes.

**500.21.7 Rate** - The contract rate for modified binder shall be as per contract agreement.

## **500.22. SPECIFICATIONS FOR CRACK PREVENTION COURSES (U.V-November 2000)**

**500.22.1 Scope** - This clause covers the provision of Stress Absorbing Membrane (SAM) AND Stress Absorbing Membrane Interlayer (SAMI) as measures to inhibit the propagation of cracks. A SAM is an elastomeric bitumen rubber membrane, which is laid over a cracked road surface, together with a covering of aggregate chips, in order to extend the life of the pavement before major treatment is carried out. SAM can be laid as a single coat or a double coat. A SAMI is a layer, which is applied to a cracked pavement surface but which is followed (within 12 months) by the application of an overlay course. A SAMI may be a material similar to that used for a SAM. It may alternatively consist of a bitumen-impregnated geotextile.

### **500.22.2 Materials**

**500.22.2.1 Binder** - Binder shall be a modified binder complying with the requirements of clause 500.23, according to the requirements of the contract, except that paving grade bitumen of 80-100 penetration complying with requirements of IS:73 shall be used in the case of a bitumen impregnated geotextile.

**500.22.2.2 Aggregate** - The requirements of clause 500.10.2.2 apply except that the Polished Stone Value requirement does not apply in the case of a SAMI. Where required by the contract, aggregate shall be pre-coated using either of the techniques permitted by clause 500.10.2.5.

**500.22.2.3 Rates of spread of binder and aggregate** - The rates of spread of binder and aggregate shall be according to one of the size alternatives in Table 500-47, as required by the contract.

**500.22.2.4 Geotextile** - The use of geotextile as prescribed for Sl.No.7 in Table 500-47 shall conform to the requirements in section 700.

### **500.22.3 Construction operations**

**500.22.3.1 Weather and seasonal limitations** - Clause 500.1.5.1 shall apply.

**500.22.3.2 Preparation of base** - The base on which the SAM, SAMI or bitumen impregnated geotextile is to be laid shall be prepared, in accordance with clause 500.1 and as directed by the engineer. The surface shall be thoroughly cleaned either by using a mechanical brush or any other equipment/method approved by the engineer. dust removed in the process shall be blown off with compressed air.

**500.22.3.3 Application of binder** - The equipment and general procedures shall all be in accordance with the Manual for Construction and Supervision of Bituminous Works. The

application temperature for modified binder shall be 160-170°C. Binder for bitumen impregnated geotextile shall be applied according to clause 500.2.4. The surface on which the binder is to be applied shall be dry.

Table 500.47. Quantity of materials required for 10 sq.m of road surface for stress absorbing membrane.

Sl. No.	Type and Width of Crack	Specification of SAM to be applied	Quantity of binder kg/10m <sup>2</sup>	Quantity of chipping
1.	Hair cracks and map cracks upto 3mm width	Single coat SAM or 2 <sup>nd</sup> coat of two coat SAM	8 – 10	0.10 m <sup>3</sup> of 5.6 mm chips
2.	Map cracks or alligator cracks 3mm to 6 mm width	Single coat SAM	10 – 12	0.11 m <sup>3</sup> of 5.6 mm chips
3.	Map cracks or alligator cracks 6mm to 9mm width	Two coat SAM 1 <sup>st</sup> coat 2 <sup>nd</sup> coat	12 – 14 8 – 10	0.12 m <sup>3</sup> of 5.6 mm and 11.2 mm chips in 1:1 ratio 0.10 <sup>3</sup> of 5.6 mm chips
4.	Cracks above 9mm width and cracked area above 50%	Two coat SAM 1 <sup>st</sup> coat 2 <sup>nd</sup> coat	14 – 16 8 - 10	0.12m <sup>3</sup> of 11.2 mm chips 0.10 <sup>3</sup> of 5.6 mm chips
5.	All types of cracks with crack width below 6mm	Single coat SAM as interlayer	8 - 10	0.10m <sup>3</sup> of 5.6mm chips
6.	All types of cracks with crack width above 6mm	Single coat SAM as interlayer	10 - 12	0.10m <sup>3</sup> of 11.2mm chips
7.	Bitumen Impregnated Geotextile			

Note :

1. Binder quantities for bitumen impregnated geotextile shall be in the range 0.9 to 1.2 litres/m<sup>2</sup>. Binder quantities outside this range are permitted according to the geotextile manufacturer's instructions and subject to the agreement of the engineer.

**500.22.3.4 Application of aggregates** - The equipment and general procedures shall all be in accordance with the Manual for Construction and Supervision of Bituminous Works. Immediately after application of the modified binder, clean, dry aggregate shall be spread uniformly on the surface.

**500.22.3.5 Sweeping** - The surface of SAMs and SAMIs shall be swept to ensure uniform spread of aggregate and that there are no loose chips on the surface.

**500.22.3.6 Two coat SAM or SAMI** - Where a two coat SAM or SAMI is required by the contract, the second coat shall be applied within 90 days of the first.

**500.22.3.7 Geotextile placement** - For bitumen impregnated geotextile, the requirements of clause 700.4.4.5 of the Ministry's Specification for Road and Bridge Works (third revision) shall apply.

**500.22.4 Opening to traffic** - Traffic may be permitted over a SAM or SAMI 2 hours after rolling, but the speed shall be limited to 20 km/h, until the following day. Speed control measures are to be approved by the engineer, prior to laying.

**500.22.5 surface finish and quality control of work** - The surface finish shall conform to the requirements of clause 900.2.

For control on the quality of materials supplied and the works carried out, the relevant provisions of section 900 shall apply.

**500.22.6 Arrangements for traffic** - During the period of construction, arrangements for traffic shall be made in accordance with the provisions of clause 100.12.

**500.22.7 Measurement for payment** - Each application of SAM, SAMI or bitumen-impregnated geotextile shall be measured as finished work, for the area specified, in square metres.

**500.22.8 Rate** - The contract unit rate for SAM, SAMI or bitumen impregnated geotextile shall be payment in full for carrying out the required operations including full compensation for all components listed in clause 500.1.8.8.2, (i) to (xi).

## **SECTION 2200**

### **SUB-STRUCTURE**

#### **2200 SPECIFICATIONS FOR SUB-STRUCTURE**

**2200.1 Description** – The work shall cover furnishing and providing of masonry or reinforced concrete sub-structure in accordance with the drawings and as per these specifications or as directed by the engineer.

**2200.2 Materials** – Materials shall conform to section 1000 of these Specifications.

**2200.3 General** – A method statement for construction indicating the following shall be submitted by the contractor for approval of the engineer, well in advance of the commencement of sub-structure :

1. Sources of materials.
2. Design, erection and removal of form work.
3. Production, transportation, laying and curing of concrete.
4. Personnel employed for execution and supervision.
5. Tests and sampling procedures.
6. Equipment details.
7. Any other point.

Arrangements for execution under water wherever necessary, shall be included in method statement.

Dimensions, lines and levels shall be set out and checked with respect to permanent reference lines and permanent bench mark.

#### **2200.4 SPECIFICATIONS FOR PIERS AND ABUTMENTS**

Masonry, form work, concrete and reinforcement for piers and abutments shall conform to relevant sections of these specifications. In case of concrete piers, the number of horizontal construction joints shall be kept minimum. Construction joints shall be avoided in splash zones unless specifically permitted by the engineer and provided they are treated in accordance with special provisions. No vertically construction joint shall be provided. The work shall conform strictly to the drawings or as directed by the engineer.

In case of tall piers and abutments, use of slip form shall be preferred. The design, erection and raising of slip form shall be subject to special specifications which will be furnished by the contractor. The concrete shall also be subject to additional specifications as necessary. All specifications and arrangements shall be subject to the prior approval of the engineer.

The surface of foundation/well cap/pile cap shall be scrapped with wire brush and all loose materials removed. In case reinforcing bars projecting from foundations are coated with cement slurry, the same shall be removed by tapping, hammering or wire brushing. Care shall be taken to remove all loose materials around reinforcements. Just before commencing masonry or concrete work, the surface shall be thoroughly wetted.

In case of solid (non-spill through type) abutments, weep holes as shown on the drawings or as directed by the engineer, shall be provided in conformity with section 2700.6.

The surface finish shall be smooth, except the earth face of abutments which shall be rough finished.

In case of abutments likely to experience considerable movement on account of back fill of approaches and settlement of foundations, the construction of the abutment shall be followed by filling up of embankment in layers to the full height to allow for the anticipated movement during construction period before casting of superstructure.

#### **2200.5 SPECIFICATIONS FOR PIER CAP AND ABUTMENT CAP.**

Form work, reinforcement and concrete shall conform to relevant sections of these specifications.

The locations and levels of pier cap/abutment cap/pedestals and bolts for fixing bearings shall be checked carefully to ensure alignment in accordance with the drawings of the bridge.

The surface of cap shall be finished smooth and shall have a slope for draining of water as shown on the drawings or as directed by the engineer. For short span slab bridges with continuous support on pier caps, the surface shall be cast horizontal. The top surface of the pedestal on which bearings are to be placed shall also be cast horizontal.

The surface on which elastomeric bearings are to be placed shall be wood float finished to a level plane which shall not vary more than 1.5 mm from straight edge placed in any direction across the area. The surface on which other bearings (steel bearings, pot bearings) are to be placed shall be cast about 25 mm below the bottom level of bearings and as indicated on the drawings.

#### **2200.6 SPECIFICATIONS FOR BALLAST WALL, RETURN WALL AND WING WALL.**

Masonry, concrete and reinforcement shall conform to relevant sections of these specifications.

In case of cantilever return walls, no construction joint shall generally be permitted. Wherever feasible, the concreting in cantilever return walls shall be carried out in continuation of the ballast wall.

For gravity type masonry and concrete return and wing wall, the surface of foundation shall be prepared in the same manner as prescribed for construction of abutment. No horizontal construction joint shall be provided. If shown on drawing or directed by the engineer, vertical construction joint may be provided. Vertical expansion gap of 20 mm shall be provided in return wall/wing wall at every 10 metre intervals or as directed for abutments or as shown on the drawings.

Form work, reinforcement and concrete in dirt/ballast wall shall conform to relevant sections of these specifications.

The finish of the surface on the earth side shall be rough while the front face shall be smooth finished.

Architectural coping for wing wall/return wall in brick masonry shall conform to section 1300.

**2200.7 Tests and standards of acceptance :** The materials shall be tested in accordance with these specifications and shall meet the prescribed criteria.

The work shall conform to these specifications and shall meet the prescribed standards of acceptance.

**2200.8 Tolerances in concrete elements :**

a.	Variation in cross-sectional dimensions	:	+ 10 mm
			- 5 mm
b.	Misplacement from specified position in plan	:	10 mm
c.	Variation the levels at the top	:	+ 10 mm
d.	Variations of reduced levels of bearing areas	:	# 5 mm
e.	Variations from plumb over full height	:	# 10mm
f.	Surface irregularities measured with 3m straight edge		
	All surfaces except bearing areas	:	5 mm
	Bearing areas	:	3 mm

**2200.9 Measurements for payment :** Masonry in sub-structure shall be measured in cubic metres in accordance with section 1300 or 1400, based on the quantities ordered or as shown on the drawing.

Concrete in sub-structure shall be measured in cubic metres in accordance with section 17000, based on the quantity ordered or as shown on the drawing. No deduction shall be made for weep holes.

Steel in concrete of sub-structures shall be measured in tones, in accordance with section 1600, based on the quantity ordered or as shown on the drawing.

Weep holes shall be measured as per section 2700, based on the quantity ordered or as shown on the drawings.

**2200.10 Rate** : The contract unit rates for masonry, concrete reinforcement and weep holes shall include all works as given in respective sections of these specifications and cover all incidental items for furnishing and providing substructure as mentioned in this section

## **SECTION 2900**

### **PIPE CULVERTS**

#### **2900 SPECIFICATIONS FOR PIPE CULVERTS**

**2900.1 Scope** - This work shall consist of furnishing and installing reinforced cement concrete pipes, of the type, diameter and length required at the locations shown on the drawings or as ordered by the engineer and in accordance with the requirements of these specifications.

**2900.2 Materials** - All materials used in the construction of pipe culverts shall conform to the requirements of section 1000.

Each consignment of cement concrete pipes shall be inspected, tested, if necessary, and approved by the engineer either at the place of manufacture or at the site before their incorporation in the works.

**2900.3. Excavation for pipe** - The foundation bed for pipe culverts shall be excavated true to the lines and grades shown on the drawings or as directed by the engineer. The pipes shall be placed in shallow excavation of the natural ground or in open trenches cut in existing embankments, taken down to levels as shown on the drawings. In case of high embankments where the height of fill is more than three times the external diameter of the pipe, the embankment shall first be built to an elevation above the top of the pipe equal to the external diameter of the pipe, and to width on each side of the pipe of not less than five times the diameter of pipe, after which a trench shall be excavated and the pipe shall be laid.

Where trenching is involved, its width on either side of the pipe shall be a minimum of 150 mm or one-fourth of the diameter of the pipe whichever is more and shall not be more than one-third the diameter of the pipe. The sides of the trench shall be as nearly vertical as possible.

The pipe shall be placed where the ground for the foundation is reasonably firm. Installation of pipes under existing bridges or culverts shall be avoided as far as possible. When during excavation the material encountered is soft, spongy or other unstable soil, and unless other special construction methods are called for on the drawings or in special provisions, such unsuitable material shall be removed to such depth, width and length as directed by the engineer. The excavation shall then be back filled with approved granular material which shall be properly shaped and thoroughly compacted up to the specified level.



Where bed-rock or boulder strata are encountered, excavation shall be taken down to at least 200 mm below the bottom level of the pipe with prior permission of the engineer and all rock/boulders in this area be removed and the space filled with approved earth, free from stone or fragmented material, shaped to the requirements and thoroughly compacted to provide adequate support for the pipe.

Trenches shall be kept free from water until the pipes are installed and the joints have hardened.

**2900.4 Bedding for pipe** - The bedding surface shall provide a firm foundation of uniform density throughout the length of the culvert, shall conform to the specified levels and grade, and shall be one of the following two types as specified on the drawings:

**1) First class bedding** - Under first class bedding, the pipe shall be evenly bedded on a continuous layer of well compacted approved granular material, shaped concentrically to fit the lower part of the pipe exterior for atleast ten per cent of its overall height or as otherwise shown on the drawings. The bedding material shall be well graded sand or another granular material passing 5.6 mm sieve suitably compacted/rammed. The compacted thickness of the bedding layer shall be as shown on the drawings and in no case shall it be less than 75 mm.

**2) Concrete cradle bedding** - When indicated on the drawings or directed by the engineer, the pipe shall be bedded in a cradle constructed of concrete having a mix not leaner than M 15 conforming to section 1700. The shape and dimensions of the cradle shall be as indicated on the drawings. The pipes shall be laid on the concrete bedding before the concrete has set.

**2900.5 Laying of pipe** - No pipe shall be laid in position until the foundation has been approved by the engineer. Where two or more pipes are to be laid adjacent to each other, they shall be separated by a distance equal to atleast half the diameter of the pipe subject to a minimum of 450 mm.

The arrangement for lifting, loading and unloading concrete pipes from factory/yard and at site shall be such that the pipes do not suffer any undue structural strain, any damage due to fall or impact. The arrangement may be got approved by the engineer.

Similarly, the arrangement for lowering the pipe in the bed shall be got approved by the engineer. It may be with tripod – pulley arrangement or simply by manual labour in a manner that the pipe is placed in the proper position without damage.

The laying of pipes on the prepared foundation shall start from the outlet and proceed towards the inlet and be completed to the specified lines and grades. In case of use of pipes with bell-mouth, the belled end shall face upstream. The pipes shall be fitted and matched so that when laid in work, they form a culvert with a smooth uniform invert.

Any pipe found defective or damaged during laying shall be removed at the cost of the contractor.

**2900.6 Jointing** - The pipes shall be jointed either by collar joint or by flush joint. In the former case, the collars shall be of RCC 150 to 200 mm wide and having the same strength as the pipes to be jointed. Caulking space shall be between 13 and 20 mm according to the diameter of the pipe. Caulking material shall be slightly wet mix of cement and sand in the ratio of 1:2 rammed with caulking irons. Before caulking, the collar shall be so placed that its centre coincides with the joint and an even annular space is left between the collar and the pipe.

Flush joint may be internal flush joint or external flush joint. In either case, the ends of the pipes shall be specially shaped to form a self centering joint with a jointing space 13 mm wide. The jointing space shall be filled with cement mortar, 1 cement to 2 sand, mixed sufficiently dry to remain in position when forced with a trowel or rammer. Care shall be taken to fill and voids and excess mortar shall be removed.

For jointing pipe lines under light hydraulic pressure, the recess at the end of the pipe shall be filled with jute braiding dipped in hot bitumen or other suitable approved compound. Pipes shall be so jointed that the bitumen ring of one pipe shall set into the recess of the next pipe. The ring shall be thoroughly compressed by jacking or by any other suitable method.

All joints shall be made with care so that their interior surface is smooth and consistent with the interior surface of the pipes. After finishing, the joint shall be kept covered and damp for at least four days.

**2900.7 Backfilling** - Trenches shall be backfilled immediately after the pipes have been laid and the jointing material has hardened. The backfill soil shall be clean, free from boulders, large roots, excessive amounts of sods or other vegetable matter, and lumps. Backfilling up to 300 mm above the top of the pipe shall be carefully done and the soil thoroughly rammed, tamped or vibrated in layers not exceeding 150 mm, particular care being taken to thoroughly consolidate the materials under the launches of the pipe. Approved pneumatic or light mechanical tamping equipment can be used.

Filling of the trench shall be carried out simultaneously on both sides of the pipe in such a manner that unequal pressures do not occur.

In case of high embankment, after filling the trench up to the top of the pipe in the above said manner, a loose fill of a depth equal to external diameter of the pipe shall be placed over the pipe before further layers are added and compacted.

**2900.8 Headwalls and other ancillary works** - Headwalls, wing walls, aprons and other ancillary works shall be constructed in accordance with the details shown on the drawings or as directed by the engineer. Masonry for the walls shall conform to Section 1300, 1400 or 1700 as applicable. Aprons shall conform to section 2500.

**2900.9 Opening to traffic-** No traffic shall be permitted to cross the pipe line unless height of filling above the top of the pipe line is at least 600 mm.

**2900.10 Measurements for payment** - R.C.C. pipe culverts shall be measured along their centre between the inlet and outlet ends in linear metres.

Selected granular material and cement concrete for pipe bedding shall be measured as laid in cubic metres. Ancillary works like headwalls, etc., shall be measured as provided for under the respective Sections.

2900.11 Rate - The contract unit rate for the pipes shall include the cost of pipes including loading, unloading, hauling, storing, laying in position and jointing complete and all incidental costs to complete the work as per these specifications.

Ancillary works such as excavation including backfilling, concrete and masonry shall be paid for separately, as provided under the respective clauses.

## **SECTION 1400**

### **STONE MASONRY**

#### **1400. SPECIFICATIONS FOR STONE MASONRY**

**1400.1 Description** - This work shall consist of the construction of structures with stones jointed together by cement mortar in accordance with the details shown on the drawings and these specifications or as approved by the engineer.

**1400.2. Materials** - All materials used in stone masonry shall confirm to section 1000 except cement mortar for stone masonry, which shall conform to clause 1300.4.

**1400.3 Personnel** - Only trained personnel shall be employed for construction and supervision.

**1400.4. Type of masonry** - The type of masonry used for structures shall be random masonry (coursed or uncoursed) or coursed rubble masonry (First sort). However, for bridge work generally, course rubble stone masonry shall be used. The actual type of masonry used for different parts of structures shall be specified on the drawings.

For facing work, ashlar masonry shall be used where indicated on the drawings.

#### **1400.5 Construction operations**

**1400.5.1 General requirements** - The dressing of stone shall be as specified for individual type masonry work and it shall also conform to the general requirements of IS: 1597 (Annexure 1400-A.1) and requirement for dressing of stone covered in IS: 1129(Annexure 1400-A.2). Other specific requirements are covered separately with respect to particular types of rubble stone work.

#### **1400.5.2 Laying**

1400.5.2.1 The masonry work shall be laid to lines, levels, curves and shapes as shown in the plan. The height in each course shall be kept same and every stone shall be fine tooled on all beds joints and face full and true. The exposed faces shall be gauged out, grooved, regulated and sunk or plain moulded as the case may be. The faces of each stone between the draft be left rough as the stone comes from quarry except where sacrificial layer is to be provided or plastering is resorted to due to aggressive environment.

1400.5.2.2. Stones shall be sufficiently wetted before laying to prevent absorption of water from mortar.

Stratified stones must be laid on their natural beds. All bed joints shall be normal to the pressure upon them.

Stones in the hearting shall be laid on their broadest face that gives a better opportunity to fill the spaces between stones.

The courses of the masonry shall ordinarily be pre-determined. They shall generally be of the same height. When there is to be variation in the height of the courses, the larger courses are to be placed at lower levels, heights of courses decreasing gradually towards the top of the wall. The practice of placing loose mortar on the course and pouring water on it to fill the gaps in stones is not acceptable. Mortar may be fluid mixed thoroughly and then poured in the joints. No dry or hollow space shall be left anywhere in the masonry and each stone shall have all the embedded faces completely covered with mortar.

In tapered walls, the beds of the stones and the planes of course should be at right angles to the batter. In case of bridge piers with batter on both sides, the course shall be horizontal.

The bed which is to receive the stone shall be cleaned, wetted and covered with a layer of fresh mortar. All stones shall be laid full in mortar both in bed and vertical joints and settled carefully in place with a wooden mallet immediately on placement and solidly embedded in mortar before it has set. Clean chips and spalls shall be wedged into the mortar joints and bed wherever necessary to avoid thick beds or joints of mortar. When the foundation masonry is laid directly on rock, the face stones of the first course shall be dressed to fit into rock snugly when pressed down in the mortar bedding over the rock. No dry or hollow space shall be left anywhere in the masonry and each stone shall have all the embedded faces completely covered with mortar. For masonry work over rock, a leveling course of 100 mm thickness and in concrete M 15 shall be laid over rock and then stone masonry work shall be laid without foundation concrete block.

Face works and hearting shall be brought up evenly but the top of each course shall not be levelled up by the use of flat chips.

For sharp corners specially in skew bridges, through stones shall be used in order to avoid spalling of corners.

In case any stone already set in mortar is disturbed or the joints broken, it shall be taken out without disturbing the adjoining stones and joints. Dry mortar and stones thoroughly cleaned from the joints and stones and the stones reset in fresh mortar. Attempt must never be made to slide one stone on top of another, freshly laid.

Shaping and dressing shall be done before the stone is laid in the work. No dressing and hammering, which will loosen the masonry, will be allowed after it is once placed. All necessary chases for joggles, dowels and clamps should be formed before hand.

Sufficient transverse bonds shall be provided by the use of bond stone extending from the front to the back of the wall and in case of thick wall from outside to the interior and vice versa. In the latter case, bond stones shall overlap each other in their arrangement.

In case headers are not available, precast headers of M 15 concrete shall be used. Cast-in-situ headers are not permitted.

Stones shall break joint on the face for at least half the height of the course and the bond shall be carefully maintained throughout.

In bond work at all angle junctions of walls, the stones at each alternate course shall be carried out into each of the respective walls so as to unite the work thoroughly.

The practice of building up thin faces tied with occasional through stones and filling up the middle with small stuff or even dry packing is not acceptable.

All quoins and the angles of the opening shall be made from selected stones, carefully squared and bedded and arranged to bond alternatively long and short in both directions.

All vertical joints shall be truly vertical. Vertical joints shall be staggered as far as possible. Distance between the nearer vertical joints of upper layer and lower shall not be less than half the height of the course.

Only rectangular shaped bond stones or headers shall be used. Bond stones shall overlap each other by 150 mm or more.

All connected masonry in a structure shall be carried up nearly at one uniform level throughout but when breaks are unavoidable the masonry shall be raked in sufficiently long steps to facilitate jointing of old and new work. The stepping of raking shall not be more than 45 degrees with the horizontal.

#### **1400.5.3. Random Masonry (uncoursed and coursed)**

**1400.5.3.1. Dressing** - Stones shall be hammer dressed on the face, the sides and beds to enable it to come in proximity with the neighboring stone. The bushing on the exposed face shall not be more than 40 mm.

**1400.5.3.2. Insertion of chips** - Chips and spalls of stone may be used wherever necessary to avoid thick mortar beds or joints and it shall be ensured that no hollow spaces are left anywhere in the masonry. The chips shall not be used below hearting stones to bring these up to the level of face stones. Use of chips shall be restricted to filling of interstices between the adjacent stones in hearting and they shall not exceed 20 per cent of the quantity of stone masonry.

**1400.5.3.3. Hearting stones** - The hearting or interior filling of the wall face shall consist of rubble stones not less than 150 mm in any direction, carefully laid, hammered down with a wooden mallet into position and solidly bedded in mortar. The hearting should be laid nearly level with facing and backing.

**1400.5.3.4. Bond stones** - Through bond stones shall be provided in masonry up to 600 mm thickness and in case of masonry above 600 mm thickness, a set of two or more bond stones overlapping each other at least by 150 mm shall be provided in a line from face to back. In case of highly absorbent types of stones (porous limestone and sandstone's, etc.,) the bond stone shall extend only about two-third into the wall, as through stones in such cases may give rise to penetration of dampness and therefore, for all thicknesses of such masonry, a set of two or more bond stones overlapping each other by at least 150 mm shall be provided. One bond stone or a set of bond stones shall be provided for every 0.50 sq. m. of the masonry surface.

**1400.5.3.5. Quoin stone** - Quoin stone i.e. stone specially selected and neatly dressed for forming an external angle in masonry work, shall not be less than 0.03 cubic metre in volume.

**1400.5.3.6. Plum stone** - The plum stones are selected long stones embedded vertically in the interior of the masonry to form a bond between successive courses and shall be provided at about 900 mm intervals.

**1400.5.3.7. Laying** - The masonry shall be laid with or without courses as specified. The quoins shall be laid header and stretcher alternately. Every stone shall be fitted the adjacent stone so as to form neat and close joint. Face stone shall extend and bond well in the back. These shall be arranged to break joints, as much as possible, and to avoid long vertical lines of joints.

**1400.5.3.8. Joints** - The face joints shall not be more than 20 mm thick, but shall be sufficiently thick to prevent stone-to-stone contact and shall be completely filled with mortar.

#### **1400.5.4. Square rubble- coursed rubble (first sort)**

**1400.5.4.1. Dressing** - Face stones shall be hammer dressed on all beds and joints so as to give them rectangular shape. These shall be square on all joints and beds. The bed joints shall be chisel drafted for at least 80 mm back from the face and for at least 40 mm for the side joints. No portion of the dressed surface shall show a depth of gap more than 6 mm from the straight edge placed on it. The remaining unexposed portion of the stone shall not project beyond the surface of bed and side joints. The requirements regarding bushing shall be the same as for random rubble masonry.

**1400.5.4.2. Hearting stones** - The hearting or interior filling of the wall face shall consist of flat bedded stone carefully laid, on prepared beds in mortar. The use of chips shall be restricted to the filling of interstices between the adjacent stones in hearting and these shall not exceed 10 per cent of the quantity of masonry. While using chips it shall be ensured that no hollow spaces are left anywhere in the masonry.

**1400.5.4.3. Bond stones** - The requirements regarding through or bond stone shall be the same as for random rubble masonry, but these, shall be provided at 1.5 metre to 1.8 metre apart clear in every course.

**1400.5.4.4. Quoin stone** - The quoins shall be of the same height of the course in which these occur and shall be formed of header stones not less than 450 mm in length. They shall be laid lengthwise alternately along each face, square in their beds which shall be fairly dressed to a depth of at least 100 mm.

**1400.5.4.5. Face stones** - Face stones shall tail into the work for not less than their heights and at least one-third of the stones shall tail into the work for a length not less than twice their height . These shall be laid as headers and stretchers alternately.

**1400.5.4.6. Laying** - The stones shall be laid on horizontal courses and all vertical joints should be truly vertical. The quoin stone should be laid header and stretcher alternately and shall be laid square on their beds, which shall be rough chisel dressed to a depth of at least 100mm.

**1400.5.4.7 Joints** - The face joints shall not be more than 10 mm thick, but shall be sufficiently thick to prevent stone-to-stone contact and shall be completely filled with mortar.

**1400.5.5 Ashlar masonry (plain ashlar) :**

**1400.5.5.1. Dressing** - Every stone shall be cut to the required size and shape, chisel dressed on all beds and joints so as to be free from all bushing. Dressed surface shall not show a depth of gap of more than 3 mm from straight edge placed on it. The exposed faces and joints, 6 mm from the face shall be fine tooled so that a straight edge can be laid along the face of the stone in contact with every point. All visible angles and edges shall be true and square and free from chippings. The corner stones (quoins) shall be dressed square and corner shall be straight and vertical.

**1400.5.5.2. Bond stones** - Through bond stones shall be provided in masonry up to 600 mm thickness and in case of masonry above 600 mm thickness, a set of two more bond stones overlapping each other at least by 150 mm shall be provided in a line from face to back. In case of highly absorbent types of stones (porous limestone and sand stones, etc.,) the bond stone shall extend only about two-third into of dampness and, therefore, for all thicknesses of such masonry a set of two or more bond stones overlapping each other by at least 150 mm shall be provided. One bond stone or a set of bond stones shall be 1.5 metres to 1.8 metres apart clear in every course.

**1400.5.5.3. Laying** - The face stone shall be laid header and stretcher alternately, the header being arranged to come as nearly as possible in the middle of stretchers above and below. Stones shall be laid in regular courses not less than 300 mm in height and all courses of the same height unless otherwise specified. No stone shall be less in width than its height or less in length than twice its height, unless otherwise specified.

**1400.5.5.4 Joints** - All joints shall be full of mortar. These shall not be less than 3 mm thick. Face joints shall be uniform throughout, and a uniform recess of 20mm depth from face shall be left with the help of a stone plate during the progress of work.

**1400.5.6. Pointing** - Pointing shall be carried out using mortar not leaner than 1:3 by volume of cement and sand or as shown on the drawing. The mortar shall be filled and pressed into the raked out joints before giving the required finish. The pointing shall conform to clause 1300.12.3 of the specification. The work shall conform to IS: 2212 (Annexure 1300.A-1). The thickness of joints shall not be less than 3 mm for Ashlar masonry. However, the maximum thickness of joints in different works shall be as follows :

Random Rubble	:	20 mm
Coursed Rubble	:	15 mm
Ashlar Masonry	:	5 mm

**1400.5.7. Curing** - Curing shall conform to clauses 1300.9 and 1300.12.5.

**1405.8. Scaffolding** - For scaffolding clause 1300.10 shall apply.

**1405.9. Weep holes** - Weep holes shall conform to clause 2700.6.

**1400.5.10. Jointing with existing structures** - For jointing with existing structures, the specifications given under clause 1300.8 shall apply.

**1400.6. Architectural coping for wings/return/parapet walls** - Architectural coping for wing/return/parapet walls shall conform to clause 1300.13.

**1400.7. Tests and standard of acceptance** - All work shall be done to the lines and levels as indicated on the drawing or as directed by the engineer subject to tolerances as specified in the specifications.

Mortar cubes shall be taken in accordance with IS: 2250 (Annexure 1300-A.2) for compressive strength, consistency of mortar and its water retentivity. The frequency of testing shall be one sample for every two cubic metres of mortar subject to a minimum 3 samples for a day's work.

**1400.8. Measurements for payment** - Stone masonry shall be measured in cubic metres. In arches, the length of arch shall be measured as the mean length between the extrados and intrados.

The work of pointing shall be measured in square metres.

Architectural coping shall be measured in linear metres.

**1400.9. Rate** - The contract unit rate for stone masonry shall include the cost of all labour, materials, tools and plant, scaffolding, sampling and testing, supervision and other expenses incidental to the satisfactory completion of the work as directed herein above.

The contract unit rate for pointing shall include erecting and removal of scaffolding, all labour, materials and equipment incidental to complete pointing, raking out joints, cleaning, wetting, filling with mortar, trowelling, pointing and watering, sampling and testing and supervision as directed in these specifications.

The contract rate for architectural coping shall include the cost of all labour, materials, tools and plant, sampling and testing and supervision as described in these specifications.



## SECTION 600

### CONCRETE

#### SPECIFICATIONS FOR CONCRETE PAVEMENT

#### DRY LEAN CEMENT CONCRETE SUB-BASE

##### 600.1. Scope

600.1.1 The work shall consist of construction of dry lean concrete sub base for cement concrete pavement in accordance with the requirements of these specifications and in conformity with the lines, grades and cross-sections shown on the drawings or as directed by the engineer. The work shall include furnishing of all plant and equipment, materials and labour and performing all operations, in connection with the work, as approved by the engineer.

600.1.2. The design parameters of dry lean concrete sub-base, viz., width, thickness, grade of concrete, details of joints, if any, etc. shall be as stipulated in the contract drawings.

##### 600.1.2. Materials

**600.1.2.1. Source of materials** - The contractor shall indicate to the engineer the source of all materials with relevant test data to be used in the lean concrete work sufficiently in advance and the approval of the engineer for the same shall be obtained at least 45 days before the scheduled commencement of the work. If the contractor later proposes to obtain the materials from a different source, he shall notify the engineer for his approval at least 45 days before such materials are to be used.

**600.1.2.2. Cement** - Any of the following types of cement may be used with prior approval of the engineer

1) Ordinary Portland Cement	IS 269
2) Portland Slag Cement	IS 455
3) Portland Pozzolana Cement	IS 1489

Copy of IS publications enclosed as Annexure 600-A.1, 600-A.2 & 600-A.3.

If the sub grade is found to consist of soluble sulphates in a concentration not more than 0.5 per cent, cement used shall be sulphates resistant and shall conform to IS 6909, copy enclosed as Annexure 600-A.4.

Cement to be used may preferably be obtained in bulk form. It shall be stored in accordance with stipulations contained in clause 100.14 and shall be subjected to acceptance test prior to its immediate use.

##### 600.1.2.3. Aggregates

600.1.2.3.1. Aggregates for lean concrete shall be natural material complying with IS 383. Copy enclosed, as Annexure 600-A.5. The aggregates shall not be alkali reactive. The limits of deleterious materials shall not exceed the requirements set out in IS 383. In case

the engineer considers that the aggregates are not free from dirt, the same may be washed and drained for at least 72 hours before batching, as directed by the engineer.

**600.1.2.3.2. Coarse aggregate** - Coarse aggregate shall consist of clean, hard, strong, dense, non-porous and durable pieces of crushed stone or crushed gravel and shall be devoid of pieces of disintegrated stone, soft, flaky, elongated, very angular or splintery pieces. The maximum size of the coarse segregate shall be 25 mm. The coarse aggregate shall comply with clause 600.2.2.4.2.

**600.1.2.3.3. Fine aggregate** - The fine aggregate shall consist of clean, natural sand or crushed stone sand or a combination of the two and shall conform to IS 383. Fine aggregate shall be free from soft particles, clay, shale, loam, cemented particles, mica, organic and other foreign matter. The fine aggregate shall comply with clause 600.2.2.4.3.

600.1.2.3.4. The coarse and fine aggregates may be obtained in either of the following manner

- 1) In separate nominal sizes of coarse and fine aggregates and mixed together intimately before use.
- 2) Separately a 25 mm nominal single size, 12.5 mm nominal size graded aggregates and fine aggregate of crushed stone dust or sand or a combination of these two.

The material after blending shall conform to the grading as indicated in Table 1.

Table 1, Aggregate gradation for dry lean concrete

Sieve designation	Percentage passing the sieve by weight
26.50 mm	100
19.00 mm	80-100
9.50 mm	55-75
4.75 mm	35-60
600.00 micron	10-35
75.00 micron	0-8

**600.1.2.4. Water** - Water used for mixing and curing of concrete shall be clean and free from injurious amounts of oil, salts, acid, vegetable matter or other substances harmful to the finished concrete. It shall meet the requirements stipulated in IS :456. Copy enclosed as Annexure 600-A.6.

**600.1.2.5. Storage of materials** - All materials shall be stored in accordance with the provisions of clause 1014 of these specifications and other relevant IS specifications. All efforts must be made to store the materials in proper places so as to prevent their deterioration or contamination by foreign matter and to ensure their satisfactory quality and fitness for use in the work. The storage place must also permit easy inspection, removal and

storage of materials. All such materials even though stored in approved godowns must be subjected to acceptance test immediately prior to their use. The requirement of storage yard specified in clause 600.2.2.9. shall also be applicable.

#### **600.1.3. Proportioning of materials for the mix**

600.1.3.1. The mix shall be proportioned with a maximum aggregate cement ratio of 151. The water content shall be adjusted to the optimum as per clause 600.1.3.2. for facilitating compaction by rolling. The strength and density requirements of concrete shall be determined in accordance with clause 600.1.6 by making trial mixes.

**600.1.3.2. Moisture content** - The right amount of water for the lean concrete in the main work shall be decided so as to ensure full compaction under rolling and shall be assessed at the time of rolling the trial strength. Too much water will cause the lean concrete to be heaving up before the wheels and picked up on the wheels of the roller and too little will lead to inadequate compaction, a low in-situ and an open-textured surface.

The optimum water content shall be determined and demonstrated by rolling during trial length construction and the optimum moisture content and degree of compaction shall be got approved from the engineer. While laying in the main work, the lean concrete shall have a moisture content between the optimum and optimum + 2 per cent, keeping in view the effectiveness of compaction achieved and to compensate for evaporation losses.

**600.1.3.3 Cement content** - The minimum cement content in the lean concrete shall not be less than 150 kg/cu. m. of concrete. If this minimum cement content is not sufficient to produce concrete of the specified strength, it shall be increased as necessary without additional cost compensation to the contractor.

**600.1.3.4 Concrete strength** - The average compressive strength of each consecutive group of 5 cubes made in accordance with clause 900.3.5.1.1 shall not be less than 10 MPa at 7 days. In addition, the minimum compressive strength of any individual cube shall not be less than 7.5 Mpa at 7 days. The design mix complying with the above clauses shall be got approved from the engineer and demonstrated in the trial length construction.

**600.1.4 Sub grade** - The sub-grade shall conform to the grades and cross sections shown on the drawings and shall be uniformly compacted to the design strength in accordance with these specifications and Specification stipulated in the contract. The lean concrete sub base shall not be laid on a sub-grade softened by rain after its final preparation ; surface trenches and soft spots, if any, must be properly back-filled and compacted to avoid any weak or soft spot. As far as possible, the construction traffic shall be avoided on the prepared sub-grade. A day before placing of the sub-base, the sub grade surface shall be given a fine spray of water and rolled with one or two passes of a smooth wheeled roller after a lapse of 2-3 hours in order to stabilise loose surface. If engineer feels it necessary, another fine spray of water may be applied just before placing sub-base.

### **600.1.5 Construction**

**600.1.5.1. General** - The pace and programme of the lean concrete sub-base construction shall be matching suitably with the programme of construction of the cement concrete pavement only after 7 days after sub-base construction.

**600.1.5.2. Batching and mixing** - The batching plant shall be capable of proportioning the materials by weight, each type of material being weighed separately in accordance with clause 600.2.9.3.2. The cement from the bulk stock shall be weighed separately from the aggregates. The capacity of batching and mixing plant shall be at least 25 per cent higher than the proposed capacity for the laying arrangements. The batching and mixing shall be carried out preferably in a forced action central batching and mixing plant having necessary automatic controls to ensure accurate proportioning and mixing. Other types of mixers shall be permitted subject to demonstration of their satisfactory performance during the trial length. The type and capacity of the plant shall be got approved by the engineer before commencement of the trial length. The weighing balances shall be calibrated by weighing the aggregates, cement, water and admixtures physically either by weighing with large weighing machine or in a weigh bridge. The accuracy of weighing scales of the batching plant shall be within  $\pm 2$  per cent in the case of aggregates and  $\pm$  per cent in the case of cement and water.

The design features of batching plant should be such that the shifting operations of the plant will not take very long time when they are to be shifted from place to place with the progress of the work.

**600.1.5.3 Transporting** - Plant mix lean concrete shall be discharged immediately from the mixer, transported directly to the point where it is to be laid and protected from the weather by covering the tippers / dumpers with tarpaulin during transit. The concrete shall be transported by tipping trucks, sufficient in number to ensure a continuous supply of material to feed the laying equipment to work at a uniform speed and in an uninterrupted manner. The lead of the batching plant to paving as specified in clause 600.1.5.5.2. will be adhered to.

**600.1.5.4 Placing** - Lean concrete shall be laid / placed by a paver with electronic sensor. The equipment shall be capable of laying the material in one layer in an even manner without segregation, so that after compaction the total thickness is as specified. The paving machine shall have high amplitude tamping bars to give good initial compaction to the sub-base.

The laying of the two-lane road sub base may be done either in full width or lane by lane. Preferably the lean concrete shall be placed and compacted across the full width of the road, by constructing it in one go or in two lanes running forward simultaneously. Transverse and longitudinal construction joints shall be staggered by 500-1000 mm and 200 – 400 mm respectively from the corresponding joints in the overlaying concrete slabs.

**600.1.5.5 Compaction** - 600.1.5.5.1 The compaction shall be carried out immediately after the material is laid and levelled. In order to ensure thorough compaction which is essential, rolling shall be continued on the full width till there is no further visible movement under the roller and the surface is closed. The minimum dry density obtained shall be 97 per cent of that achieved during the trial length construction vide clause 600.1.7. The densities achieved at the edges i.e. 0.5 m from the edge shall not be less than 95 per cent of that achieved during the trial construction vide clause 600.1.7.

600.1.5.5.2 The spreading, comprising and finishing of the lean concrete shall be carried out as rapidly as possible and the operation shall be so arranged as to ensure that the time between the mixing of the first batch of concrete in any transverse section of the layer and the final finishing of the same shall not exceed 90 minutes when the concrete temperature is above 25 degree celsius. This period may be reviewed by the engineer in the light of the results of the trial run but in no case shall it exceed 2 hours. Work shall not proceed when the temperature of the concrete exceeds 30 degree celsius. If necessary, chilled water or addition of ice may be resorted to for bringing down the temperature. It is desirable to stop concreting when the ambient temperature is above 35 degree celsius. After compaction has been completed, roller shall not stand on the compacted surface for the duration of the curing period except during commencement of next day's work near the location where the work was terminated the previous day.

600.1.5.5.3 Double drum smooth-wheeled vibratory rollers of minimum 80 to 100 kN static weight are considered to be suitable for rolling dry lean concrete. In case of any other roller is proposed, the same shall be got approved from the engineer, after demonstrating its performance. The number of passes required to obtain maximum compaction depends on the thickness of the lean concrete, the compactibility of the mix, and the weight and type of the roller etc. And the same as well as the total requirement of rollers for the job shall be determined during trial run by measuring the in-situ density and the scale of the work to be undertaken.

**600.1.5.5.4. In addition to the number of passes required for compaction there shall be a preliminary pass without vibration to bed the lean concrete down and again a final pass without vibration to remove roller marks and to smoothen the surface.**

**Special care and attention shall be exercised during compaction near joints, kerbs, channels, side forms and around gullies and manholes. In case adequate compaction is not achieved by the roller at these points, use of plate vibrator shall be made, if so directed by the engineer.**

600.1.5.5.5. The final lean concrete surface on completion of compaction and immediately before overlaying, shall be well closed, free from movement under roller and free from ridges, low spots, cracks, loose material, pot holes, ruts or other defects. The final surface

shall be inspected immediately on completion of all loose, segregated or defective areas shall be corrected by using fresh lean concrete material laid and compacted as per Specification. For repairing honeycombed surface, concrete with aggregates of size 10 mm and below shall be spread and compacted. It is necessary to check the level of the rolled surface for compliance. Any level/thickness deficiency should be corrected after applying concrete with aggregates of size 10 mm and below after roughening the surface. Similarly the surface regularity also should be checked with 3 m straight edge. The deficiency should be made up with concrete with aggregates of size 10 mm and below.

600.1.5.5.6. Segregation of concrete in the dumpers shall be controlled by premixing each fraction of the aggregates before loading in the bin of the batching plant, by moving the dumper back and forth while discharging the mix on it and other means. Even paving operation shall be such that the mix does not aggregate.

**600.1.5.6 Joints** - Construction and longitudinal joints shall be provided as per the drawing. At longitudinal or transverse construction joints, unless vertical forms are used, the edge of compacted material shall be cut back to a vertical face where the correct thickness of the properly compacted material has been obtained.

**600.1.5.7 Curing** - As soon as the lean concrete surface is compacted, curing shall commence. One of the following two methods shall be adopted

a) The initial curing shall be done by spraying with liquid curing compound. The curing compound shall be white pigmented or transparent type with water retention index of 90 per cent when tested in accordance with BS 7542. Curing compound shall be sprayed immediately after rolling is complete. As soon as the curing compound has lost its tackiness, the surface shall be covered with wet hessian for three days.

b) Curing shall be done by covering the surface by gunny bags/hessian, which shall be kept continuously moist for 7 days by sprinkling water.

**600.1.6 Trial mixes** - The contractor shall make trial of dry lean concrete with moisture contents like 5.0, 5.5, 6.0, 6.5 and 7.0 per cent using cement content specified aggregate grading but without violating the requirement of aggregate-cement ratio specified in clause 601.3.1. Optimum moisture and density shall be established by preparing cubes with varying moisture contents. Compaction of the mix shall be done in three layers with vibratory hammer fitted with a square or rectangular foot as described in clause 903.5.1.1. After establishing the optimum moisture, a set of six cubes shall be cast at that moisture for the determination of compressive strength on the 3<sup>rd</sup> and the seventh day. Trial mixes shall be repeated if the strength is not satisfactory either by increasing cement content or using higher grade of cement. After the mix design is approved, the contractor shall construct a trial section in accordance with clause 600.1.7.

If during the construction of the trial length, the optimum moisture cement determined as above is found to be unsatisfactory, the contractor may make suitable changes in the moisture content to achieve a satisfactory mix. The cube specimens prepared with the

changed moisture content should satisfy the strength requirement. Before production of the mix, natural moisture content of the aggregate should be determined on a day-to-day basis so that the moisture content could be adjusted. The mix finally designed should neither stick to the rollers nor become too dry resulting in ravelling of surface.

#### **600.1.7 Trial length**

600.1.7.1. The trial length shall be constructed at least 14 days in advance of the proposed date of commencement of work. At least 30 days prior to the construction of the trial length, the contractor shall submit for the engineer's approval a "Method Statement" giving detailed description of the proposed materials, plant, equipment, mix proportion, and procedure for batching, mixing, laying, compaction and other construction procedures. The engineer shall also approve the location and length of trial construction which shall be a minimum of 60 m length and for full width of the pavement. The trial length shall contain the construction of at least one transverse construction joint involving hardened concrete and freshly laid sub-base. The construction of trial length will be repeated till the contractor proves his ability to satisfactorily construct the sub base.

600.1.7.2. In order to determine and demonstrate the optimum moisture content which results in the maximum dry density of the mix compacted by the rolling equipment and the minimum cement content that is necessary, to achieve the strength stipulated in the drawing, trial mixes shall be prepared as per clause 600.1.6.

After the construction of the trial length, the in-situ density of the freshly laid material shall be determined by sand replacement method with 20 cm dia density cone. Three density holes shall be made at locations equally spaced along a diagonal the bisects the trial length; average of these densities shall be determined. These main density holes shall not be made in the strip 50 cm from the edges. The average density obtained from the three samples collected shall be the reference density and is considered as 100 per cent. The field density of regular work will be compacted with this reference density in accordance with clauses 600.1.5.5.1. and 900.3.5.1.2. A few cores may be cut as per the instructions of the engineer to check segregation or any other deficiency.

600.1.7.4. The hardened concrete shall be cut over 3 m width and reversed to inspect the bottom surface for any segregation taking place. The trial length shall be constructed after making necessary changes in the gradation of the mix to eliminate segregation of the mix. The lower surface shall not have honey-combing and the aggregates shall not be held loosely at the edges.

600.1.7.5. The trial length shall be outside the main works . The main work shall not start until the trial length has been approved by the engineer. After approval has been given, the materials, mix proportions, moisture content, mixing, laying, compaction plant and construction procedures shall not be changed without the approval of the engineer.

**600.1.8 Tolerances for surface regularity, level, thickness, density and strength** - The tolerances for surface regularity, level, thickness density and strength shall conform to the requirements given in clause 900.3.5. Control of quality of materials and works shall be exercised by the engineer in accordance with Section 900.

**600.1.9 Traffic** - No heavy commercial vehicles like trucks and buses shall be permitted on the lean concrete sub-base after its construction. Light vehicles if unavoidable may, however, be allowed after 7 days of its construction with prior approval of the engineer.

**600.1.10 Measurements for payment** - The unit of measurement for dry lean concrete pavement shall be the cubic metre of concrete placed, based on the net plan areas for the specified thickness shown on the drawings or as directed by the engineer.

**600.1.11 Rate** - The contract unit rate payable for dry lean concrete sub-base shall be payment in full for carrying out the required operations including full compensation for all labour, materials and equipment, mixing, transport, placing, compacting, finishing, curing, testing and incidentals to complete the work as per specifications, all royalties, fees, storage and rents where necessary and all leads and lifts.

## **600.2 SPECIFICATIONS FOR CEMENT CONCRETE PAVEMENT**

### **600.2.1. Scope**

600.2.1.1. The work shall consist of construction reinforced, dowel jointed, plain cement concrete pavement in accordance with the requirements of these specifications and in conformity with the lines, grades and cross sections shown on the drawings. The work shall include furnishing of all plant and equipment, materials and labour and performing all operations in connection with the work, as approved by the engineer.

600.2.1.2. The design parameters, viz., thickness of pavement slab, grade of concrete, joint details etc. shall be as stipulated in the drawings.

### **600.2.2. Materials**

**600.2.2.1. Source of materials** - The contractor shall indicate to the engineer the source of all materials to be used in the concrete work with relevant test data sufficiently in advance, and the approval of the engineer for the same shall be obtained at least 45 days before the scheduled commencement of the work. If the contractor later proposes to obtain materials from a different source, he shall notify the engineer for his approval, at least 45 days before such materials are to be used with relevant test data.

**600.2.2.2. Cement** - Any of the following types of cement capable of achieving the design strength may be used with prior approval of the engineer, but **the preference should be to use at least the 43 Grade or higher.**

(1) Ordinary Portland Cement, 33 Grade, IS 269 (Annexure 400-A.1)



- (2) Ordinary Portland Cement, 43 Grade IS 8112 (Annexure 600-A.7)
- (3) Ordinary Portland Cement, 53 Grade, IS 12269 (Annexure 600-A.8)

If the soil around has soluble salts like sulphates in excess to 0.5 per cent, the cement used shall be sulphate resistant and shall conform to IS 12230. Copy enclosed as Annexure 600-A.9.

Guidance may be taken from IS23, "Handbook for Concrete Mixes" for ascertaining the minimum 7 days strength of cement required to match with the design concrete strength. Cement to be used may preferably be obtained in bulk form. If cement in paper bags are proposed to be used, there shall be bag-splitters with the facility to separate pieces of paper bags and dispose them of suitably. No paper pieces shall enter the concrete mix. Bulk cement shall be stored in accordance with clause 1000.14. The cement shall be subjected to acceptance test just prior to its use.

**600.2.2.3. Admixtures** - Admixtures conforming to IS 6925 and IS 9103 copies enclosed an Annexure 600-A.10 & 600-A.11 shall be permitted to improve workability of the concrete or extension of setting time, on satisfactory evidence that they will not have any adverse effect on the properties of concrete with respect to strength, volume change, durability and have no deleterious effect on steel bars. The particulars of the admixture and the quantity to be used, must be furnished to the engineer in advance to obtain his approval to be used, must be furnished to the engineer in advance to obtain his approval before use. Satisfactory performance of the admixtures should be proved both on the laboratory concrete trial mixes and in trial paving works. If air entraining admixture is used, the total quantity of air in air-entrained concrete as a percentage of the volume of the mix shall be  $5 \pm 1.5$  per cent for 25 mm nominal size aggregate.

#### **600.2.2.4. Aggregates**

600.2.2.4.1. Aggregates for pavement concrete shall be natural material complying with IS 383 but with a Los Angeles Abrasion Test result not more than 35 per cent. The limits of deleterious materials shall not exceed the requirements set out in IS 383.

The aggregates shall be free from chert, flint, chalcedony or other silica in a form that can react with the alkalies in the cement. In addition, the total chlorides content expressed as chloride ion content shall not exceed 0.06 per cent by weight and the total sulphate content expressed as sulphuric anhydride (SO<sub>3</sub>) shall not exceed 0.25 per cent by weight.

**600.2.2.4.2. Coarse aggregate** - Coarse aggregate shall consist of clean, hard, strong, dense, non-porous and durable pieces of crushed stone or crushed gravel and shall be devoid of pieces of disintegrated stone, soft, flaky, elongated, very angular or splintery pieces. The maximum size of coarse aggregate shall not exceed 25 mm for pavement concrete. Continuously graded or gap aggregates may be used, depending on the grading more than 2 per cent shall be used in the concrete mix. The aggregates shall be tested for

soundness in accordance with IS 2386 (Part – 5). After 5 cycles of testing the loss shall not be more than 12 per cent if sodium sulphate solution is used or 18 per cent if magnesium sulphate solution is used.

Dumping and stacking of aggregates shall be done in an approved manner. In case the engineer considers that the aggregates are not free from drift, the same may be washed and drained for at least 72 hours before batching as directed by the engineer.

**600.2.2.4.3. Fine aggregate** - The fine aggregate shall consist of clean natural sand or crushed stone sand or a combination of the two and shall conform to IS 383 Annexure 600-A.5. Fine aggregate shall be free from soft particles, clay, shale, loam, cemented particles, mica and organic and other foreign matter. The fine aggregate shall not contain deleterious substances more than the following

Clay lumps	4.0 per cent
Coal and lignite	1.0 per cent
Material passing IS Sieve No. 75 micron	4.0 per cent

**600.2.2.5. Water** - Water used for mixing and curing of concrete shall be clean and free from injurious amount of oil, salt, acid, vegetable matter or other substances harmful to the furnished concrete. It shall meet the requirements stipulated in IS 456 Annexure 600-A.6.

**600.2.2.6 Mild steel bars for dowels and tie bars** - These shall conform to the requirements to IS 432, IS 1139 and IS 1786 Copies enclosed as Annexures 600-A.11, 600-A.12 and 600-A.13 respectively as relevant. The dowel bars shall conform to Grade S 240 and tie bars to Grade S 415 of I.S.

**600.2.2.7 Premoulded joint filler** - Joint filler board for expansion joints which are proposed for use only at some abutting structures like bridges and culverts shall be of 20-25 mm thickness within a tolerance of  $\pm 1.5$  mm and of a firm compressible material and complying with the requirements of IS 1838 or BS Specification clause 2630 or Specification for Highway Works, Vol. I clause 1015. It shall be 25 mm less in depth than the thickness of the slab within a tolerance of  $\pm 3$  mm and provided to the full width between the side forms. It shall be in suitable lengths which shall not be less than one lane width. Holes to accommodate dowel bars shall be accurately bored or punched out to give a sliding fit on the dowel bars.

**600.2.2.8 Joint sealing compound** - The joint sealing compound shall be of hot poured, elastomeric type or cold polysulphide type having flexibility, resistance to age hardening and durability. If the sealant is of hot poured type it shall conform to AASHTO M282 and cold applied sealant shall be in accordance with BS 5212 (Part 2).

**600.2.2.9 Storage of materials** - All materials shall be stored in accordance with the provisions of clause 1000.14 of the specifications and other relevant IS specifications. All efforts must be to store the materials in proper places so as to prevent their deterioration or contamination by foreign matter and to ensure their satisfactory quality and fitness for the work. The platform where aggregates are stock piled shall be levelled with 15 cm of watered, mixed and compacted granular sub-base material. The area shall have slope and drain to drain off rain water. The storage space must also permit easy inspection, removal and storage of the materials. Aggregates of different sizes shall be stored in partitioned stack-yards. All such materials even though stored in approved godowns must be subjected to acceptance test as per clause 903 of these specifications immediately prior to their use.

### **600.2.3 Proportioning of concrete**

600.2.3.1. After approval by the engineer of all the materials to be used in the concrete, the contractor shall submit the mix design based on weighed proportions of all ingredients for the approval of the engineer. The mix design shall be submitted at least 30 days prior to the paving the trial length and the design shall be based on laboratory trial mixes using the approved materials and methods as per IS 10262, copy enclosed as Annexure 600-A-12, or on the basis of any other rational method agreed to by the engineer. Guidance in this regard can also be obtained from IS SP 23 Handbook on Concrete Mixes. The target mean strength for the design mix shall be determined as indicated in clause 900.3.5.2. The mix design shall be based on the flexural strength of concrete.

**600.2.3.2. Cement content** - The cement content shall not be less than 350 kg per cu. m. of concrete. If this minimum cement content is not sufficient to produce in the field, concrete of the strength specified in the drawings / design, it shall be increased as necessary without additional compensation under the contract. The cement content shall, however, not exceed 425 kg per cu. m. of concrete.

### **600.2.3.3. Concrete strength**

600.2.3.3.1 While designing the mix in the laboratory, correlation between flexural and compressive strengths of concrete shall be established on the basis of at least thirty tests on samples. However, quality control in the field shall be exercised on the basis of flexural strength. It may, however, be ensured that the materials and mix proportions remain substantially unaltered during the daily concrete production. The water content shall be the minimum required to provide the agreed workability for full compaction of the concrete to the required density as determined by the trial mixes or other means approved by the engineer and the maximum free water cement ratio shall be 0.50.

600.2.3.3.2 The ratio between the 7 and 28 day strengths shall be established for the mix to be used in the slab in advance, by testing pairs of beams and cubes at each stage on at least six batches of trial mix. The average strength of the 7 day cured specimens shall be divided by the average strength of the 28 day specimens for each batch, and the ratio "R" shall be determined. The ratio 'R' shall be expressed to three decimal places.

600.2.3.3.3 If during the construction of the trial length or during normal working, the average value of any four consecutive 7 day test results falls below the required 7 day strength as derived from the value of 'R', then the cement content of the concrete shall, without extra payment, be increased by 5 per cent by weight or by an amount agreed by the engineer. The increased cement content shall be maintained at least until for four corresponding 28 day strengths have been assessed for its conformity with the requirements as per clause 602.3.1. Whenever the cement content is increased, the concrete mix shall be adjusted to maintain the required workability.

#### **600.2.3.4 Workability**

600.2.3.4.1. The workability of the concrete at the point of placing shall be adequate for the concrete to be fully compacted and finished without undue flow. The optimum workability for the mix to suit the paving plant being used shall be determined by the contractor and approved by the engineer. The control of workability in the field shall be exercised by the slump test as per IS 1199, copy enclosed as Annexure 600-A.13.

600.2.3.4.2. The workability requirement at the Batching Plant and paving site shall be established by slump tests during trial paving. These requirements shall be established from season to season and also when the lead from Batching plant site to the paving site changes. The workability shall be established for the type of paving equipment available. A slump value in the range of  $30 \pm 15$  mm is reasonable for paving works but this may be modified depending upon the site requirement and got approved by the engineer. These tests shall be carried out on every truck/dumper at Plant site and paving site initially when the work commences but subsequently the frequency can be reduced to alternate trucks or as per the instructions of the engineer.

#### **600.2.3.5 Design mix**

600.2.3.5.1 The contractor shall carry out laboratory trials of design mixes with the materials from the approved sources to be used. Trial mixes shall be made in presence of the engineer or his representative and the design mix shall be subject to the approval of the engineer. They shall be repeated if necessary until the proportions that will produce a concrete which complies in all respects with this specifications, and conforms to the requirement of the design / drawings have been determined.

600.2.3.5.2 The proportions determined as a result of the laboratory trial mixes may be adjusted if necessary during the construction of the trial length. Thereafter, neither the materials nor the mix proportions shall be varied in any way except with the written approval of the engineer.

600.2.3.5.3 Any change in the source of materials or mix proportions proposed by the contractor during the course of work shall be assessed by making laboratory trial mixes and the construction of a further trial length unless approval is given by the engineer for minor

adjustments like compensation for moisture content in aggregates or minor fluctuations in the grading of aggregate.

**600.2.4 Sub – base** - The cement concrete pavement shall be laid over the sub-base constructed in accordance with the relevant drawings and specifications contained in clause 600.1. If the sub-base is found damaged at some places or it has cracks wider than 10 mm, it shall be repaired with fine cement concrete or bituminous concrete before laying separation layer. Prior to laying of concrete it shall be ensured that the separation membrane as per clause 600.2.5 is placed in position and the same is clean of dirt or other extraneous materials and free from any damage.

**600.2.5. Separation membrane** - A separation membrane shall be used between the concrete slab and the sub-base. Separation membrane shall be impermeable plastic sheeting 125 micron thick laid flat without creases. Before placing the separation membrane, the sub-base shall be swept clean of all the extraneous materials using air compressor. Wherever overlap of plastic sheets is necessary, the same shall be at least 300 mm and any damaged sheeting shall be replaced at the contractor's expense. The separation membrane may be nailed to the lower layer with concrete nails.

#### **600.2.6 Joints**

600.2.6.1 The location and type of joints shall be as shown in the drawing. Joints shall be constructed depending upon their functional requirement as detailed in the following paragraphs. The location of the joints should be transferred accurately at the site and mechanical saw cutting of joints done as per stipulated dimensions. It should be ensured that the full required depth of cut is made from edge to edge of the pavement. Transverse and longitudinal joints in the pavement and sub-base shall be staggered so that they are not coincident vertically and are at least 1 m and 0.3 m apart respectively. Sawing of joints shall be carried out with diamond studded blades soon after the concrete has hardened to take the load of the sawing machine and personnel without damaging the texture of the pavement. Sawing operation could start as early as 6-8 hours of depending upon the season.

##### **600.2.6.2. Transverse joints**

600.2.6.2.1. Transverse joints shall be contraction and expansion joints constructed at the spacing described in the Drawings. Transverse joints shall be straight within the following tolerances along the intended line of joints which is the straight line transverse to the longitudinal axis of the carriageway at the position proposed by the contractor and agreed to by the engineer, except at road junctions or roundabouts where the position shall be as described in the drawings

- (1) Deviations of the filler board in the case of expansion joints from the intended line of the joint shall not be greater than  $\pm 10$  mm.
- (2) The best fit straight line through the joint grooves as constructed shall be not more than 25 mm from the intended line of the joint.

- (3) Deviations of the joint groove from the best fit straight line of joint shall not be greater than 10 mm.
- (4) Transverse joints on each side of the longitudinal joint shall be in line with each other and of the same type and width. Transverse joints shall have a sealing groove which shall be sealed in compliance with clause 600.2.11.

**600.2.6.2.2. Contraction joints** - Contraction joints shall consist of a mechanical sawn joint groove, 3 to 5 mm wide and  $\frac{1}{4}$  to  $\frac{1}{3}$  depth of the slab  $\pm$  5 mm or as stipulated in the drawings and dowel bars complying with clause 600.2.6.5. and as detailed in the drawings.

The contraction joints shall be cut as soon as the concrete has undergone initial hardening and is hard enough to take the load of joint sawing machine without causing damage to the slab.

**600.2.6.2.3. Expansion joints** - The expansion joints shall consist of a joint filler board complying with clause 600.2.2.7 and dowel bars complying with clause 600.2.6.5. and as detailed in the drawings. The filler board shall be positioned vertically with the prefabricated joint assemblies along the line of the joint within the tolerances given in clause 600.2.6.2.1. and at such depth below the surface as will not impede the passage of the finishing straight edges or oscillating beams of the paving machines. The adjacent slabs shall be completely separated from each other by providing joint filler board. Space around the dowel bars, between the sub-base and the filler board shall be packed with a suitable compressible material to block the flow of cement slurry.

**600.2.6.3. Transverse construction joint** - Transverse construction joint shall be placed whenever concreting is completed after a day's work or is suspended for more than 30 minutes. These joints shall be provided at the regular location of contraction joints using dowel bars. The joint shall be made butt type. At all construction joints, steel bulk heads shall be used to retain the concrete while the surface is finished. The surface of the concrete laid subsequently shall conform to the grade and cross sections of the previously laid pavement. When positioning of bulk head / stop-end is not possible, concreting to an additional 1 or 2 m length may be carried out enable the movement of joint cutting machine so that joint grooves may be formed and the extra 1 or 2 m length is cut out and removed subsequently after concrete has hardened.

**600.2.6.4. Longitudinal joint**

600.2.6.4.1. The longitudinal joints shall be saw cut as per details of the joints shown in the drawing. The groove may be cut after the final set of the concrete. Joints should be sawn to at least  $\frac{1}{3}$  the depth of the slab  $\pm$  5 mm as indicated in the drawing.

600.2.6.4.2. Tie bars shall be provided at the longitudinal joints as per dimensions and spacing shown in the drawing and in accordance with clause 600.2.6.6.

#### **600.2.6.5 Dowel bars**

600.2.6.5.1 Dowel bars shall be mild steel rounds in accordance with clause 600.2.2.6 with details/dimensions as indicated in the drawing and free from oil, dirt, loose rust or scale. They shall be straight, free of irregularities and burring restricting slippage in the concrete. The sliding ends shall be sawn or cropped cleanly with no protrusions outside the normal diameter of the bar. The dowel bar shall be supported on cradles/dowel chairs in pre-fabricated joint assemblies positioned prior to the construction of the slabs or mechanically inserted with vibration into the plastic concrete by a method which ensures correct placement of the bars besides full re-compaction of the concrete around the dowel bars.

600.2.6.5.2 Unless shown otherwise on the drawings, dowel bars shall be positioned at mid depth of the slab within a tolerance of  $\pm 20$  mm, and centred equally about intended lines of the joint within a tolerance of  $\pm 25$  mm. They shall be aligned parallel to the finished surface of the slab and to the centre line of the carriageway and to each other within tolerances given hereunder, the compliance of which shall be checked as per clause 600.2.10.7.

- (1) For bars supported on cradles prior to the laying of the slab ;
  - (a) All bars in a joint shall be within  $\pm 3$  mm per 300 mm length of bar
  - (b) 2/3 rd of the bars shall be within  $\pm 2$  mm per 300 mm length of bar
  - (c) No bar shall differ in alignment from an adjoining bar by more than 3 mm per 300 mm length of bar in either the horizontal or vertical plane
  - (d) Cradles supporting dowel bar shall not extend across the line of joint i.e. no steel bar of the cradle assembly shall be continuous across the joint.

- (2) For all bars inserted after laying of the slab ;
  - (a) Twice the tolerance for alignment as indicated in (1) as above

600.2.6.5.3. Dowel bars, supported on cradles in assemblies, when subject to load of 110 N applied at either end in either the vertical or horizontal direction (upwards and downwards and both directions horizontally) shall conform to be within the following limits

- (1) Two-thirds of the number of bars of any assembly tested shall not deflect more than 2 mm per 300 mm length of bar
- (2) The remainder of the bars in that assembly shall not deflect more than 3 mm per 300 mm length of bar.

**600.2.6.5.4. The assembly of dowel bars and supporting cradles, including the joint filler board in the case of expansion joints, shall have the following degree of rigidity when fixed in position -**

- (1) For expansion joints, the deflection of the top edge of the filler board shall be not greater than 13 mm, when a load of 1.3 kN is applied perpendicular to the vertical face of the joint filler board and distributed over a length of 600 mm by means of a bar or timber packing, at mid depth and midway between individual fixings, or 300 mm from either end of any length

of filler board, if a continuous fixing is used. The residual deflection after removal of the load shall be not more than 3 mm.

(2) The joint assembly fixings to sub-base shall not fail under the 1.3 kN load applied for testing the rigidity of the assembly but shall fail before the load reaches 2.6 kN.

(3) The fixings for contraction joint shall not fail under 1.3 kN load and shall fail before the load reaches 2.6 kN when applied over a length of 600 mm by means of a bar or timber packing placed as near to the level of the line of fixings as practicable.

(4) Fixings shall be deemed to fail when there is displacement of the assemblies by more than 3 mm with any form of fixing, under the test load. The displacement shall be measured at the nearest part of the assembly to the centre of the bar or timber packing.

600.2.6.5.5. Dowel bars shall be covered by a thin plastic sheath for at least two-thirds of the length from one end for dowel bars in contraction joints or half the length plus 50 mm for expansion joints. The sheath shall be tough, durable and of an average thickness not greater than 1.25 mm. The sheathed bar shall comply with the following pull-out tests

(1) Four bars shall be taken at random from stock and without any special preparation shall be covered by sheaths as required in this clause. The ends of the dowel bars which have been sheathed shall be cast centrally into concrete specimens 150 x 150 x 600 mm, made of the same mix proportions to be used in the pavement, bar with a maximum nominal aggregate size of 20 mm and cured in accordance with IS 516. At 7 days a tensile load shall be applied to achieve a movement of the bar of at least 0.25 mm. The average bend stress to achieve this movement shall not be greater than 0.14 Mpa.

**600.2.6.5.6. For expansion joints, a closely fitting cap 100 mm long consisting of waterproofed cardboard or an approved synthetic material like PVC or GI pipe shall be placed over the sheathed end of each dowel bar. An explosion space at least equal in length to the thickness of the joint filler board shall be formed between the end of the cap and the end of the dowel bar by using compressible sponge. To block the entry of cement slurry between dowel and cap it may be taped.**

#### **600.2.6.6. Tie bars**

600.2.6.6.1. Tie bars in longitudinal joints shall be deformed steel bars of strength 415 Mpa complying with IS :1786 and in accordance with the requirements given below. The bars shall be free from oil, dirt, loose rust and scale.

600.2.6.6.2. Tie bars projecting across the longitudinal joint shall be protected from corrosion for 75 mm on each side of the joint by a protective coating of bituminous paint with the approval of the engineer. The coating shall be dry when the tie bars are used.

600.2.6.6.3. Tie bars in longitudinal joints shall be made up into rigid assemblies with adequate supports and fixings to remain firmly in position during the construction of the slab. Alternatively, tie bars at longitudinal joints may be mechanically or manually inserted into



the plastic concrete from above by vibration using a method which ensures correct placement of the bars and recompaction of the concrete around the tie bars.

600.2.6.6.4. Tie bars shall be positioned to remain within the middle third of the slab depth as indicated in the drawings and approximately parallel to the surface and approximately perpendicular to the line of the joint, with the centre of each bar on the intended line of the joints below the joint groove.

### **600.2.7 Weather and seasonal limitations**

**600.2.7.1. Concreting during monsoon months** - When concrete is being placed during monsoon months and when it may be expected to rain, sufficient supply of tarpaulin or other proof cloth shall be provided along the line of the work. Any time when it rains, all freshly laid concrete which had not been covered for curing purposes shall be adequately protected. Any concrete damaged by rain shall be removed and replaced. If the damage is limited to texture, it shall be retextured in accordance with the directives of the engineer.

**600.2.7.2. Concreting in hot weather** - No concreting shall be done when the concrete temperature is above 30 degree Centigrade. Besides, in adverse conditions like high temperature, low relative humidity, excessive wind velocity, imminence of rains etc., if so desired by the engineer, tents on mobile trusses may be provided over the freshly laid concrete for a minimum period of three hours as directed by the engineer. The temperature of the concrete mix on reaching the paving site shall not be more than 30 degree Centigrade. To bring down the temperature, if necessary, chilled water or ice flakes should be made use of.

No concreting shall be done when the concrete temperature is below 5 degree centigrade and the temperature is descending.

### **600.2.8 Side Forms, rails and guidewires**

**600.2.8.1. Side forms and rails** - All side forms shall be of mild steel of depth equal to the thickness of pavement or slightly less to accommodate the surface regularity of the sub-base. The forms can be placed on series of steel packing plates or shims to take care of irregularity of sub-base. They shall be sufficiently robust and rigid to support the weight and pressure caused by a paving equipment. Sideforms for use with wheeled paving machines shall incorporate metal rails firmly fixed at a constant height below the top of the forms. The forms and rails shall be firmly secured in position by not less than 3 stakes / pins per each 3 m length so as to prevent movement in any direction. Forms and rails shall be straight within a tolerance of 3 mm in 3 m and when in place shall not settle in excess of 1.5 mm in 3 mm while paving is being done. Forms shall be cleaned and oiled immediately before each use. The forms shall be bedded on a continuous bed of low moisture content lean cement mortar or concrete and set to the line and levels shown on the drawings within tolerances  $\pm 10$  mm and  $\pm 3$  mm respectively. The bedding shall not extend under the slab and there shall be no vertical step between adjacent forms of more than 3 mm. The forms shall be got inspected

from the engineer for his approval before 12 hours on the day before the construction of the slab shall not be removed until at least 12 hours afterwards.

600.2.8.2. At all times sufficient forms shall be used and set to the required alignment for at least 200 m length of pavement immediately in advance of the paving operations, or the anticipated length of pavement to be laid within the next 24 hours whichever is more.

#### **600.2.8.3. Use of guidewires**

600.2.8.3.1. Where slip form paving is proposed, a guidewire shall be provided along both sides of the slab. Each guidewire shall be at a constant height above and parallel to the required edges of the slab as described in the contract/drawing within a vertical tolerance of  $\pm 3$  mm. Additionally, one of the wires shall be kept at a constant horizontal distance from the required edge of the pavement as indicated in the contract / drawing within a lateral tolerance of  $\pm 10$  mm.

600.2.8.3.2. The guidewires shall be supported on stakes not more than 8 m apart by connectors capable of fine horizontal and vertical adjustment. The guidewire shall be tensioned on the stakes so that a 500 gram weight shall produce a deflection of not more than 20 mm when suspended at the mid point between any pair of stakes. The ends of the guidewires shall be anchored to fixing point or winch and not on the stakes.

600.2.8.3.3. The stakes shall be positioned and the connectors maintained at their correct height and alignment from 12 hours on the day before concreting takes place until 12 hours after finishing of the concrete. The guidewire shall be erected and tensioned on the connectors at any section for at least 2 hours before concreting that section.

600.2.8.3.4. The contractor shall submit to the engineer for his approval of line and level, the stakes and connectors which are ready for use in the length of road to be constructed by 12 hours on the working day before the day of construction of slab. Any deficiencies noted by the engineer shall be rectified by the contractor who shall then re-apply for approval of the affected stakes. Work shall not proceed until the engineer has given his approval. It shall be ensured that the stakes and guidewires are not affected by the construction equipment when concreting is in progress.

#### **600.2.9. Construction**

**600.2.9.1. General** - A systems approach may be adopted for construction of the pavement, and the Method Statement for carrying out the work, detailing all the activities including indication of time-cycle, equipment, personnel, etc., shall be got approved from the engineer before the commencement of the work. The above shall include the type, capacity and make of the batching and mixing plant besides the hauling arrangement and paving equipment. The capacity of paving equipment, batching plant as well as all the ancillary equipment shall be adequate for a paving rate of atleast 300 m in one day.

**600.2.9.2. Batching and mixing** - Batching and mixing of the concrete shall be done at a central batching and mixing plant with automatic controls, located at a suitable place which takes into account sufficient space for stockpiling of cement, aggregates and stationery water tanks. This shall be, however, situated at an approved distance, duly considering the properties of the mix and the transporting arrangements available with the contractor.

**600.2.9.3. Equipment for proportioning of materials and paving**

600.2.9.3.1. Proportioning of materials shall be done in the batching plant by weight, each type of material being weighed separately. The cement from the bulk stock may be weighed separately from the aggregates and water shall be measured by volume. Wherever properly graded aggregate of uniform quality cannot be maintained as envisaged in the mix design, the grading of aggregates shall be controlled by appropriate blending techniques. The capacity of batching and mixing plant shall be at least 25 per cent higher than the proposed capacity of the laying / paving equipment.

**600.2.9.3.2. Batching plant and equipment**

**(1) General** - The batching plant shall include minimum four bins, weighing hoppers, and scales for the fine aggregate and for each size of coarse aggregate. If cement is used in bulk, a separate scale for cement shall be included. The weighing hoppers shall be properly sealed and vented to preclude dust during operation. Approved safety devices shall be provided and maintained for the protection of all personnel engaged in plant operation, inspection and testing. The batch plant shall be equipped with a suitable non-resettable batch counter which will correctly indicate the number of batches proportioned.

**2) Bins and hoppers** - Bins with minimum number of four adequate separate compartments shall be provided in the batching plant.

**3) Automatic weighing devices** – Batching plant shall be equipped to proportion aggregates and bulk cement by means of automatic weighing devices using load cells.

**4) Mixers** – Mixers shall be pan type, reversible type or any other mixer capable of combining the aggregates, cement, and water into a thoroughly mixed and uniform mass within the specific mixing period, and of discharging the mixture, without segregation. Each stationery mixer shall be equipped with an approved timing device which will automatically lock the discharge lever when the drum has been charged and release it at the end of the mixing period. The device shall be equipped with a bell or other suitable warning device adjusted to give a clearly audible signal each time the lock is released. In case of failure of the timing device, the mixer may be used for the balance of the day while it is being repaired, provided that each batch is mixed 90 seconds or as per the manufacturer's recommendation. The mixer shall be equipped with a suitable non-resettable batch counter which shall correctly indicate the number of batches mixed.

The mixers shall be cleaned at suitable intervals. The pick up and throw-over blades in the drum or drums shall be repaired or replaced when they are worn down 20 mm or more. The contractor shall (1) have available at the job site a copy of the manufacturer's design, showing dimensions and arrangements of blades in reference to original height and depth, or (2) provide permanent marks on blade to show points of 20 mm wear from new conditions. Drilled holes of 5 mm diameter near each end and at midpoint of each blade are recommended. Batching plant shall be calibrated in the beginning and thereafter at suitable interval not exceeding 1 month.

**(5) Control cabin** – An air-conditioned centralised control cabin shall be provided for automatic operation of the equipment.

**600.2.9.3.3. Paving equipment** - The concrete shall be placed with an approved fixed form or slip from paver with independent units designed to (1) spread, (ii) consolidate, screed and float-finish, (iii) texture and cure the freshly placed concrete in one complete pass of the machine in such a manner that a maximum of hand finishing will be necessary and so as to provide a dense and homogeneous pavement in conformity with the plans and specifications. The paver shall be equipped with electronic controls to control / sensor line and grade from either or both sides of the machine.

Vibrators shall operate at a frequency of 8300 to 9600 impulses per minute under load at a maximum spacing of 60 cm. The variable vibration setting shall be provided in the machine.

**600.2.9.3.4. Concrete saw** - The contractor shall provide adequate number of concrete saws with sufficient number of diamond – edge saw blades. The saw machine shall be either electric or petrol/diesel driven type. A water tank with flexible hoses and pump shall be made available in this activity saw in good working condition. The concreting work shall not commence if the saws are not in working condition.

#### **600.2.9.4. Hauling and placing of concrete**

600.2.9.4.1. Freshly mixed concrete from the central batching and mixing plant shall be transported to the paver site by means of trucks/tippers of sufficient capacity and approved design in sufficient numbers to ensure a constant supply of concrete. Covers shall be used for protection of concrete against the weather. The trucks/tippers shall be capable of maintaining the mixed concrete in a homogeneous state and discharging the same without segregation and loss of cement slurry. The feeding to the paver is to be regulated in such a way that the paving is done in an uninterrupted manner with a uniform speed throughout the days work.

**600.2.9.4.2. Placing of concrete** - Concrete mixed in central mixing plant shall be transported to the site without delay and the concrete which, in the opinion of the engineer, has been mixed too long before laying will be rejected and shall be removed from the site. The total time taken from the addition of the water to the mix, until the completion of the

surface finishing and texturing shall not exceed 120 minutes when concrete temperature is less than 25 degree centigrade and 90 minutes when the concrete temperature is between 25 degree centigrade to 30 degree centigrade. Trucks/tippers delivering concrete shall not run on plastic sheeting nor shall they run on completed slabs until after 28 days of placing the concrete. The paver shall be capable of paving the carriageway as shown in the drawings, in a single pass and lift.

600.2.9.4.3. Where fixed form pavers are to be used, forms shall be fixed in advance as per clause 600.2.8. of the specifications. Before any paving is done, the site shall be shown to the engineer, in order to verify the arrangement for paving besides placing of dowels, tie-bars etc., as per the relevant clauses of this Specification. The mixing and placing of concrete shall progress only at such a rate as to permit proper finishing, protecting and curing of the pavement.

600.2.9.4.4. In all cases, the temperature of the concrete shall be measured at the point of discharge from the delivery vehicle.

600.2.9.4.5. The addition of water to the surface of the concrete to facilitate the finishing operations will not be permitted except with the approval of the engineer when it shall be applied as a mist by means of approved equipment.

600.2.9.4.6. If considered necessary by the engineer, the paving machines shall be provided with approved covers to protect the surface of the slab under construction from direct sunlight and rain or hot wind.

600.2.9.4.7. While the concrete is still plastic, its surface shall be brush textured in compliance with clause 600.2.9.8 and the surface and edges of the slab cured by the application of a sprayed liquid curing membrane in compliance with clause 600.2.9.9. After the surface texturing, but before the curing compound is applied, the concrete slab shall be marked with the chainage at every 100 m interval.

600.2.9.4.8. As soon as the side forms are removed, edges of the slabs shall be corrected wherever irregularities have occurred by using fine concrete composed of one part of cement to 3 parts of fine chips and fine aggregate under the supervision of the engineer.

600.2.9.4.9. If the requirement of clause 902.4. for surface regularity fails to be achieved on two consecutive working days, then normal working shall cease until the cause of the excessive irregularity has been identified and remedied.

#### **600.2.9.5. Construction by fixed form paver**

600.2.9.5.1 The fixed form paving train shall consist of separate powered machines which spread, compact and finish the concrete in a continuous operation.

600.2.9.5.2 The concrete shall be discharged without segregation into a hopper spreader which is equipped with means for controlling its rate of deposition on to the sub-base. The spreader shall be operated to strike off concrete upto a level requiring a small amount of cutting down by the distributor of the spreader. The distributor or spreader shall strike off the concrete to the surcharge adequate to ensure that the vibratory compactor thoroughly compacts the layer. If necessary, poker vibrators shall be used adjacent to the side forms and edges of the previously constructed slabs. The vibratory compactor shall be set to strike off the surface slightly high so that it is cut down to the required level by the oscillating beam. The machine shall be capable of being rapidly adjusted for changes in average and differential surcharge necessitated by change in slab thickness or crossfall.

#### **600.2.9.6.Construction by slip form paver**

600.2.9.6.1. The slip form paving train shall consist of power machine which spreads, compacts and finishes the concrete in a continuous operation. The slip form paving machine shall compact the concrete by internal vibration and shape it between the side forms with either a conforming plate or by vibrating and oscillating finishing beams. The concrete shall be deposited without segregation in front of slip form paver across the whole width and to a height which at all times is in excess of the required surcharge. The deposited concrete shall be struck off to the necessary average and differential surcharge by means of the strike off plate or a screw auger device extending across the whole width of the slab. The equipment for striking off-the concrete shall be capable of being rapidly adjusted for changes of the average and differential surcharge necessitated by change in slab thickness or crossfall.

600.2.9.6.2. The level of the conforming plate and finishing beams shall be controlled automatically from the guide wires installed as per clause 600.2.8 by sensors attached at the four corners of the slip form paving machine. The alignment of the paver shall be controlled automatically from the guide wire by at least one set of sensors attached to the paver. The alignment and level of ancillary machines for finishing, texturing and curing of the concrete shall be automatically controlled relative to the guide wire or to the surface and edge of the slab.

600.2.9.6.3. Slip-form paving machines shall have vibrators of variable output, with a maximum energy output of not less than 2.5 KW per metre width of slab per 300 mm depth of slab for a laying speed upto 1.5 m per minute or pro-rata for higher speeds. The machines shall be of sufficient mass to provide adequate reaction during spreading and paving operations on the traction units to maintain forward movements during the placing of concrete in all situations.

600.2.9.6.4. If the edges of the slip formed slab slump to the extent that the surface of the top edge of the slab does not comply with the requirements of clause 600.2.14, then special measures approved by the engineer shall be taken to support the edges to the required

levels and work shall be stopped until such time as the contractor can demonstrate his ability to slip form the edges to the required levels.

**600.2.9.7 Construction by hand-guided method** - Areas in which hand-guided methods of construction become indispensable shall be got approved by the engineer in writing in advance. Such work may be permitted only in restricted areas in small lengths. Work shall be carried out by skilled personnel as per methods approved by the engineer. The acceptance criteria regarding level, thickness, surface regularity, texture, finish, strength of concrete and all other quality control measures shall be same as in the case of machine laid work.

#### **600.2.9.8 Surface texture**

600.2.9.8.1 After the final regulation of the slab and before the application of the curing membrane, the surface of concrete slab shall be brush-textured in a direction at right angles to the longitudinal axis of the carriageway.

600.2.9.8.2 The brushed surface texture shall be applied evenly across the slab in one direction by the use of a wire brush not less than 450 mm wide but longer brushes are preferred. The brush shall be made of 32 gauge tape wires grouped together in tufts spaced at 10 mm centres. The tufts shall contain an average of 14 wires and initially be 100 mm long. The brush shall have two rows of tufts. The rows shall be 20 mm apart and the tufts in the other row. The brush shall be replaced when the shortest tuft wears down to 90 mm long.

600.2.9.8.3 The texture depth shall be determined by the Sand Patch Test as described in clause 600.2.12. This test shall be performed at least once for each day's paving and wherever the engineer considers it necessary at times after construction as under

Five individual measurements of the texture depth shall be taken at least 2 m apart anywhere along a diagonal line across a lane width between points 50 m apart along the pavement. No measurement shall be taken within 300 mm of the longitudinal edges of a concrete slab constructed in one pass.

600.2.9.8.4 Texture depths shall not be less than the minimum required when measurements are taken as given in Table 600-2 nor greater than a maximum average of 1.25 mm.

Table 2 - Texture depth

Time of test	Number of measurements	Required texture depth (mm)	
		Specified value	Tolerance
1. Between 24 hours and 7 days after the constn of the slab or until the slab is first used by vehicles.	An average of 5 measurements	100	± 0.25
2. Not later than 6 weeks before the road is opened to public traffic.	An average of 5 measurements	1.00	+ 0.25 - 0.35

600.2.9.8.5 After the application of the brushed texture, the surface of the slab shall have a uniform appearance.

600.2.9.8.6 Where the texture depth requirements are found to be deficient, the contractor shall make good the texture across the full lane width over length directed by the engineer, by retexturing the hardened concrete surface in an approved manner.



#### **600.2.9.9 Curing**

600.2.9.9.1. Immediately after the surface texturing, the surface and sides of the slab shall be cured by the application of approved resin-based aluminised reflective curing compound which hardens into an impervious film or membrane with the help of a mechanical sprayer.

Curing compounds shall contain sufficient flake aluminium in finely divided dispersion to produce a complete coverage of the sprayed surface with a metallic finish. The compound shall become stable and impervious to evaporation of water from the surface of the concrete within 60 minutes of application and shall be of approved type. The curing compounds shall have a water retention efficiency index of 90 per cent in accordance with BS Specification No. 7542.

600.2.9.9.2. The curing compound shall not react chemically with the concrete and the film or membrane shall not crack, peel or disintegrate within three weeks after application. Immediately prior to use, the curing compound shall be thoroughly agitated in its containers. The rate of spread shall be in accordance with the manufacturer's instructions checked during the construction of the trial length and subsequently whenever required by the engineer. The mechanical sprayer shall incorporate an efficient mechanical device for continuous agitation and mixing of the compound during spraying.

600.2.9.9.3. In addition to spraying of curing compound, the fresh concrete surface shall be protected for at least 3 hours by covering the finished concrete pavement with tents as described in clause 600.2.7.2. during adverse weather conditions as directed by the engineer. After three hours, the pavement shall be covered by moist hessian and the same shall then be kept damp for a minimum period of 14 days after which time the hessian may be removed. The hessian shall be kept continuously moist. All damaged/torn hessian shall be removed and replaced by new hessian on a regular basis. Code of practice for curing of cement concrete pavements are given in Annexure 600 – A.14.

600.2.9.9.4. The contractor shall be liable at his expense to replace any concrete damaged as a result of incomplete curing or cracked on a line other than that of a joint.

#### **600.2.10.Trial length**

600.2.10.1. The trial length shall be constructed at least one month in advance of the proposed start of concrete paving work. At least one month prior to the construction of the trial length, the contractor shall submit for the engineer's approval a detailed method statement giving description of the proposed materials, plant, equipment and construction methods. All the major equipments like paving train, batching plant, tippers, etc., proposed in the construction are to be approved by the engineer before their procurement. No trials of new materials, plant, equipment or construction methods, nor any development of them shall be permitted either during the construction of trial length or in any subsequent paving work,

unless they form part of further, approved trials. These trial lengths shall be constructed away from the carriageway but with at least a sub-base layer below it.

600.2.10.2. The contractor shall demonstrate the materials, plant, equipment and methods of construction that are proposed for concrete paving, by first constructing a trial length of slab, at least 60 m but not more than 300 m long for mechanised construction and at least 30 m long for hand guided methods. If the first trial is unsatisfactory, then contractor shall have to demonstrate his capability to satisfactorily construct the pavement in subsequent trials.

600.2.10.3. The trial length shall be constructed in two parts over a period of comprising at least part of two separate working days, with a minimum of 30 m constructed each day for mechanised construction and a minimum of 15 m on each day for hand guided construction. The trial length shall be constructed at a similar rate (speed, around 1m/hr) to that which is proposed for the main work.

600.2.10.4. Transverse joints and longitudinal joints of each type that are proposed for dowel-jointed un-reinforced concrete slabs in the main work shall be constructed and assessed in the trial length. If in the trial length the construction of expansion joint and longitudinal joint is not demonstrated, the first 2 expansion joints and at least the first 150 m of longitudinal construction joint for mechanized paving in the main work, shall be considered as the trial length for these joints.

600.2.10.5. The trial length shall comply with the Specification in all respects, with the following additions and exceptions

#### **600.2.10.5.1. Surface levels and regularity**

(1) In checking for compliance with clause 900.3.5 the levels shall be taken at intervals at the location specified in this clause along any time or lines parallel to the longitudinal centre line of the trial length.

(2) The maximum number of permitted irregularities of pavement surface shall comply with the requirements of clause 900.2.4. Shorter trial lengths shall be assessed pro-rata based on values for a 300 m length.

#### **600.2.10.5.2. Joints**

(i) Alignment of dowel bars shall be inspected as described in clause 602.10.7 in any two consecutive transverse joints. If the position or alignment of the dowel bars at one of these joints does not comply with clause 600.2.6.5, if that joint remains the only one that does not comply after the next 3 consecutive joints of the same type have been inspected, then the method of placing dowels shall be deemed to be satisfactory. In order to check sufficient joints for dowel bar alignment without extending the trial length unduly, the contractor may, by agreement with the engineer, construct joints at more frequent joint intervals than the normal spacing required in the contract.

(ii) If there are deficiencies in the first expansion joint there is constructed as a trial, the next expansion joint shall be a trial joint. Should this also be deficient, further trial expansion joints shall be made as part of the trial length which shall not form part of the permanent works, unless agreed by the engineer.

#### **600.2.10.5.3. Density**

(iii) Density shall be assessed as described in clause 602.3.3. from at least 3 cores drilled from each part of the trial length.

#### **602.10.5.4. Position of tie bars**

(iv) Compliance with clause 600.2.6.6. for the position and alignment of tie bars shall be checked by drilling additional cores from the slab unless they can be determined from cores from the slab unless they can be determined from cores taken for density.

#### **600.2.10.6. Approval and acceptance**

600.2.10.6.1. Approval of the materials, plant, equipment and construction methods shall be given when a trial length complies with the Specification. The contractor shall not proceed with normal working until the trial length has been approved and any earlier defective trial lengths have been removed, unless that can be remedied to the satisfaction of the engineer. If the engineer does not notify the contractor of any deficiencies in any trial length within 10 days after the completion of that trial length, the contractor may assume that the trial length, and the materials, plant, equipment and construction methods adopted are acceptable.

600.2.10.6.2. When approval has been given, the materials, plant, equipment and construction methods shall not thereafter be changed, except for normal adjustments and maintenance of plant, without the approval of the engineer. Any changes in materials, plant, equipment, and construction methods shall entitle the engineer to require the contractor to lay a further trial length as described in the clause to demonstrate that the changes will not adversely affect the permanent works.

600.2.10.6.3. Trial lengths which do not comply with the Specification, with the exception of areas which are deficient only in surface texture and which can be remedied in accordance with clause 600.2.9.8.6. shall be removed immediately upon notification of deficiencies by the engineer and the contractor shall construct a further trial length.

#### **600.2.10.7. Inspection of dowel bars**

**600.2.10.7.1. Compliance with clause 600.2.6.5. for the position and alignment of dowel bars at construction and expansion joints shall be checked by measurements relative to the side forms or guide wires.**

600.2.10.7.2. When the slab has been constructed, the position and alignment of dowel bars and any filler board shall be measured after carefully exposing them in the plastic concrete across the whole width of the slab. When the joint is an expansion joint, the top of the filler board shall first be exposed sufficiently in the plastic concrete to permit measurement of any

lateral or vertical displacement of the board. During the course of normal working, these measurements shall be carried out in the pavement section at the end of day's work by extending slab length by 2 m. After sawing the transverse joint groove, the extended 2 m slab shall be removed carefully soon after concrete has set to expose dowels over half the length. These dowels can be tested for tolerances.

600.2.10.7.3. If the position and alignment of the bars in a single joint in the slab is unsatisfactory then the next two joints shall be inspected. If only one joint of the three is defective, the rate of checking shall be increased to one joint per day until the engineer is satisfied that compliance is being achieved. In the event of non-compliance in two or more successive joints, the contractor shall revert to the construction of fresh trial lengths and make any necessary alteration to concrete mix, paving plant or methods until the dowel bar position and alignment are satisfactory.

600.2.10.7.4. After the dowel bars have been examined, the remainder of the concrete shall be removed over a width of 500 mm on each side of the line of the joint and reinstated to the satisfaction of the engineer. The dowels shall be inserted on both sides of the 1 m wide slab by drilling holes and grouting with epoxy mortar. Plastic sheath as per clause 600.2.6.5.5. shall be provided on dowels on one of the joints. The joint groove shall be widened and sealed as per clause 600.2.11.

#### **600.2.11. Preparation and sealing of joint grooves**

**600.2.11.1. General** - All transverse joints in surface slabs shall be sealed using sealants described in clause 600.2.2.8. Joints shall not be sealed before 14 days after construction.

#### **600.2.11.2. Preparation of joint grooves for sealing**

600.2.11.2.1. Joint grooves usually are not constructed to provide the minimum width specified in the drawings when saw cut joints are adopted. They shall be widened subsequently by sawing before sealing. Depth/width gauges shall be used to control the dimension of the groove.

600.2.11.2.2. If rough arrises develop when grooves are made, they shall be ground to provide a chamfer approximately 5 mm wide. If the groove is at an angle up to 10 degree from the perpendicular to the surface, the overhanging edge of the sealing groove shall be sawn or ground perpendicular. If spalling occurs or the angle of the former is greater than 10 degrees, the joint sealing groove shall be sawn wider and perpendicular to the surface to encompass the defects up to a maximum width, including any chamfer, of 35 mm for transverse joints and 20 mm for longitudinal joints. If the spalling cannot be so eliminated then the arrises shall be repaired by an approved thin bonded arris repair using cementitious materials.

600.2.11.2.3. All grooves shall be cleaned of any dirt or loose material by air blasting with filtered, oil-free compressed air. If need arises the engineer may instruct cleaning by

pressurised water jets. Depending upon the requirement of the sealant manufacturer, the sides of the grooves may have to be sand blasted to increase the bondage between sealant and concrete.

600.2.11.2.4. The groove shall be cleaned and dried at the time of priming and sealing.

600.2.11.2.5. Before sealing the temporary seal provided for blocking the ingress of dirt, soil etc., shall be removed. A highly compressible heat resistant paper-backed debonding strip as per drawing shall be inserted in the groove to serve the purpose of breaking the bond between sealant and the bottom of the groove and to plug the joint groove so that the sealant may not leak through the cracks. The width of debonding strip shall be more than the joint groove width so that it is held tightly in the groove. In the case of longitudinal joints, heat resistant tapes may be inserted to block the leakage through bottom of the joint.

### **600.2.11.3. Sealing with sealants**

600.2.11.3.1. When sealants are applied, an appropriate primer shall also be used if recommended by the manufacturer and it shall be applied in accordance with their recommendation. The sealant shall be applied within the minimum and maximum drying times of the primer recommended by the manufacturer. Priming and sealing with applied sealants shall not be carried out when the naturally occurring temperature in the joint groove to be sealed is below 7 degree centigrade.

600.2.11.3.2. If hot applied sealant is used it shall be heated and applied from a thermostatically controlled, indirectly heated preferably with oil jacketed melter and pourer having recirculating pump and extruder. For large road projects, sealant shall be applied with extruder having flexible loose hose and nozzle. The sealant shall not be heated to a temperature higher than the safe heating temperature and not for a period longer than the safe heating period, as specified by the manufacturer. The dispenser shall be cleaned out at the end of each day in accordance with the manufacturer's recommendations and reheated material shall not be used.

600.2.11.3.3. Cold applied sealants with chemical formulation like polysulphide may be used. These shall be mixed and applied within the time limit specified by the manufacturer. If primers are recommended they shall be applied neatly with an appropriate brush. The Movement Accommodation Factor (MAF) shall be more than 10 per cent.

600.2.11.3.4 He sealants applied at construction phase of the slabs would result in bulging of the sealant over and above the slab. Therefore, the contractor in consultation with the engineer, shall establish the right temperature and time for applying the sealant. Thermometer shall be hung on a pole in the site for facilitating control during the sealing operation.

600.2.11.3.5 Sealant shall be applied, slightly to a lower level than the slab with a tolerance of  $5 \pm 2$  mm.

600.2.11.3.6 During sealing operation, it shall be seen that no air bubbles are introduced in the sealant either by vapours or by the sealing process.

**600.2.11.4. Testing of applied sealants** - Manufacturer's certificate shall be produced by the contractor for establishing that the sealant is not more than six months old and stating that the sealant complies with the relevant standard as in clause 600.2.2.8. The samples shall meet the requirement of AASHTO M 282 Annexure 600-A.21 for hot applied sealant or BS 5212 (Part-2) for cold applied sealant.

#### **600.2.11.5 Requirements of primer and sealing compound**

#### **600.2.12 Measurement of texture depth - Sand Patch Method**

600.2.12.1. The following apparatus shall be used

- (1) A cylindrical container of 25 ml internal capacity
- (2) A flat wooden disc 64 diameter with a hard rubber disc, 1.5 mm thick, stuck to one face, the reverse face being provided with a handle.
- (3) Dry natural sand with a rounded particle shape passing a 300 micron IS sieve and retained on a 150 micron IS sieve.

**600.2.12.2. Method** - The surface to be measured shall be dried, any extraneous mortar and loose material removed and the surface swept clean using a wire brush both at right angles and parallel to the carriageway. The cylindrical container shall be filled with the sand, tapping the base 3 times on the surface to ensure compaction, and striking off the sand level with the top of the cylinder. The sand shall be poured into a heap on the surface to be treated. The sand shall be spread over the surface, working the disc with its face kept flat in a circular motion so that is spread into a circular patch with the surface depressions filled with sand to the level of peaks.

600.2.12.3 The diameter of the patch shall be measured to the nearest 5 mm. The texture depth of concrete surface shall be calculated from  $31000/(D \times D)$  mm where D is the diameter of the patch in mm.

**600.2.13. Opening to traffic** - No vehicular traffic shall be allowed to run on the finished surface of a concrete pavement within a period of 28 days of its construction and until the joints are permanently sealed. The road may be opened to regular traffic after completion of the curing period of 28 days and after sealing of joints is completed including the construction of shoulder, with the written permission of the engineer.

**600.2.14 Tolerances for surface regularity, level, thickness and strength** - The tolerances for surface regularity, level, thickness and strength shall conform to the requirements given in clause 900.3.5. Control of quality of materials and works shall be exercised by the engineer in accordance with Section 900.

**600.2.15. Measurements for payment**

600.2.15.1. Cement concrete pavement shall be measured as a finished work in square metres with specified thickness. The volume to be paid for will be calculated on the basis of thickness and plans shown on the project drawings and adjusted for the deficiency in thickness. No additional payment shall be made for extra thickness of the slab. The full payment will be made to this item after 28 days strength of the concrete is found to be satisfactory.

The unit for measurement for concrete pavement shall be the cubic metre of concrete placed, based on the net plan areas for the specified thickness shown the Drawings or directed by the engineer. The rate shall include all provisions of this Specification and shall include the provision of all materials polythene film, concrete, stock piling, mixing, transport, placing, compacting, finishing, curing together with all formwork, and including testing and submission of test certificates and records. No deduction shall be made in measurement for openings provided that the area of each is less than 0.5 sq. m. The unit rate as entered in the Bill of Quantities shall also include the full costs of construction, expansion, contraction, and longitudinal joints. It shall also include joint filler, caulking rod, debonding strip, sealant primer, joint sealant, dowel bar and tie rod.

**600.2.15.2. Pavement thickness** - All precautions and care shall be taken to construct pavement having uniform thickness as called for on the plans.

Thickness of the cement concrete pavement shall be calculated on the basis of level data of the cement concrete pavement and the underlying sub-base taken on a grid of 5m x 3.5m or 6.25 m x 3.5 m, the former measurement being in longitudinal direction.

A day's work is considered as a 'lot' for calculating the average thickness of the slab. In calculating the average thickness, individual measurements which are in excess of the specified thickness by more than 10 mm shall be considered as the specified thickness plus 10 mm.

Individual areas deficient by more than 25 mm shall be verified by the engineer by ordering core cutting and if in his opinion the deficient areas warrant removal, they shall be removed and replaced with concrete of the thickness shown on the plans.

When the average thickness for the lot is deficient by the extent shown in Table 600-3, the contract unit price will be adjusted as per this Table.





Table 3 Payment adjustment for deficiency in thickness

Deficiency in the average Thickness of day's work	Percent of contract Unit price payable
Upto 5 mm	100
6-10 mm	87
11-15 mm	81
16-20 mm	75
21-25 mm	70

In the stretch where deficiency of average thickness is more than 25 mm, the section whose thickness is deficient by 26 mm or more is identified with the help of cores. Such slabs shall be removed and reconstructed at the cost of the contractor. During such rectification work, care shall be taken to replace full slab and to the full depth.

**600.2.16 Rate** - The contract unit rate for the construction of the cement concrete shall be payment is full for carrying out the operations required for the different items of the work as per these specifications including full compensation for all labour, tools, plant, equipments, testing and incidentals to complete the work as per specifications, providing all materials to be incorporated in the work including all royalties, fees, storage, rents where necessary and all leads and lifts.

### **600.3 SPECIFICATIONS FOR ROLLED CEMENT CONCRETE BASE**

#### **600.3.1. Scope**

600.3.1.1. The work shall consist of construction of rolled concrete base course for cement concrete pavement in accordance with the requirements of these specifications and in conformity with the lines, grades and cross sections shown on the drawings or as directed by the engineer. The work shall include furnishing of all plant and equipment, material and labour and performing all operations in connection with the work, as approved by the engineer.

600.3.1.2 The design parameters of rolled cement concrete base course viz., width, thickness, grade of concrete, details of joints, if any, etc. shall be as stipulated in the contract drawings.

#### **600.3.2 Materials**

**600.3.2.1. Source of materials** - The contractor shall indicate to the engineer the source of all materials to be used in the lean concrete work with relevant test data sufficiently in advance and the approval of the engineer for the same shall be obtained at least 60 days before the scheduled commencement of the work. If the contractor later proposes to obtain the materials from a different source, he shall notify the engineer for his approval at least 60 days before such materials are to be used.

**600.3.2.2 Cement** - Any of the following types of cement may be used with prior approval of the engineer.

(1) Ordinary Portland Cement	IS 269, 8112 or 12269
(2) Portland Slag Cement	IS 455
(3) Portland Pozzolana Cement	IS 1489

If the sub grade is found to consist of soluble sulphates in a concentration more than 0.5 per cent, cement used shall be sulphate resistant and shall conform to IS 12230 (Annexure 600-A-9). Cement to be used may preferably be obtained in bulk form. It shall be stored in accordance with stipulations contained in clause 1000.14 and shall be subjected to acceptance test prior to its immediate use.

### **600.3.2.3 Aggregates**

600.3.2.3.1 Aggregates for lean concrete shall be natural materials complying with IS 383. The aggregates shall not be alkali reactive. The limits of deleterious materials shall not exceed the requirements set out in IS 383(Annexure 600-A.2). In case the engineer considers that the aggregates are not free from dirt, the same may be washed and drained for at least 72 hours before batching as directed by the engineer.

**600.3.2.3.2 Coarse aggregates** - Coarse aggregates shall consist of clean, hard, strong, dense, non-porous and durable pieces of crushed stone or crushed gravel and shall be devoid of pieces of disintegrated stone, soft, flaky, elongated, very angular or splintery pieces. The maximum size of the coarse aggregate shall be 25 mm. The coarse aggregate shall comply with the clause 600.2.2.4.2.

**600.3.2.3.3. Fine aggregate** - The fine aggregate shall consist of clean mutual sand or crushed stone sand or a combination of the two and shall conform to IS 383. Fine aggregate shall be free from soft particles, clay, shale, loam, cemented particles, mica, organic and other foreign matter. The fine aggregate shall comply with the clause 600.2.4.3.

600.3.2.3.3. The coarse and fine aggregates may be obtained in either of the following manner -

- (1) In square nominal sizes of coarse and fine aggregates and mixed together intimately before use.
- (2) Separately as 25 mm nominal single size, 12.5 mm nominal size graded aggregate and fine aggregate of crushed stone dust or sand or a combination of these two.

**The material after blending shall conform to the grading as indicated in Table 600-4 below**

**Table 4 Aggregate gradation for day lean concrete**

<b>Sieve designation</b>	<b>Percentage passing the sieve by weight</b>
<b>37.5 mm</b>	<b>100</b>
<b>19.0 mm</b>	<b>80-100</b>
<b>9.5 mm</b>	<b>55-80</b>
<b>4.75 mm</b>	<b>35-60</b>
<b>600 micron</b>	<b>10-35</b>
<b>75 micron</b>	<b>0-8</b>

**600.3.2.4 Water** - Water used for mixing and curing of concrete shall be clean and free from injurious amount of oil, salt, acid, vegetable matter or other substances harmful to the finished concrete. It shall meet the requirements stipulated in IS 456.(Annexure 600-A.2)

**600.3.2.5 Storage of materials** - All materials shall be stored in accordance with the provisions of clause 1000.14 of these specifications, and other relevant IS specifications. All efforts must be made to store the materials in proper places so as to prevent their deterioration or contamination by foreign matter and to ensure their satisfactory quality and fitness for the work. The storage place must also permit easy inspection, removal and storage of materials. All such materials even though stored in approved godowns must be subjected to acceptance test immediately prior to their use. The requirement of storage yard specified in clause 600.2.2.9 shall be applicable.

**600.3.3 Proportioning of materials for the mix**

600.3.3.1. The mix shall be proportioned with a maximum aggregate cement ratio of 15 : 1. After the approval of all the materials to be used in the concrete, the contractor shall submit the mix design based on weighed proportion of all ingredients for the approval of the engineer. The mix design shall be submitted at least 30 days prior to the paving of trial length and design shall be done based on the laboratory trials using approved materials and methods. The water content shall be adjusted to the optimum as per clause 600.3.3.2. for facilitating compaction by rolling. The target mean strength for the design mix as well as acceptance Specification of concrete shall be in accordance with clause 900.3.5.2. The mix design shall be based on the flexural strength of concrete.

**600.3.3.2 Moisture content** - The right amount of water for the rolled concrete in the main work shall be decided for ensuring full compaction under rolling and shall be assessed at the time of rolling the trial length. Too much water will cause the concrete to be picked up on the wheels of the roller and too little will lead to inadequate compaction, a low in-situ strength and an open textured surface. The optimum water content shall be determined in accordance with clause 600.3.7. and demonstrated by rolling during trial length construction ; and the optimum moisture content and degree of compaction shall be got approved by the engineer. While laying, in the main work, the rolled concrete shall have a moisture content

between the optimum and optimum + 2 per cent, keeping in view the effectiveness of compaction achieved and to compensate for evaporation losses.

**600.3.3.3 Cement content** - The minimum cement content in the rolled concrete shall not be less than 150 kg/cu. m. of concrete. If this minimum cement content is not sufficient to produce concrete of the specified strength, it shall be increased as necessary without additional compensation under the contract.

**600.3.3.4 Concrete strength** - The flexural strength as specified shall be the governing criteria for approval of the mix. While designing the mix in the laboratory, correlation between flexural and compressive strengths of concrete shall be established on the basis of tests on samples for use at a later date to verify the in situ flexural strength of rolled concrete through testing of cores.

At least a batch of two beam and cube specimens, one each for 3 day and 7 day strength testing shall be cast for every 100 cum or part thereof of concrete placed during construction. On each day's work not less than four beams and four cubes shall be made.

A ratio between the 3 and 7 day strengths shall be established for the mix to be used. This will help in assessing the fall in strength, if any in advance so that corrective action can be taken for the future work.

**600.3.4 Subgrade** - The sub grade shall conform to the grades and cross sections shown on the drawings and shall be uniformly compacted to the design strength in accordance with these specifications and the Specification stipulated in the contract. The rolled concrete base shall not be laid on a sub grade softened by rain after its final preparation ; any surface trenches, soft spots etc., must be properly back-filled and compacted to avoid any weak or soft spot. As far as possible, the construction traffic shall be avoided on the prepared subgrade. A day before placing of the sub-base, the subgrade surface shall be given a fine spray of water and rolled with one or two passes of a smooth wheeled roller after a lapse of 2-3 hours in order to stabilise the loose surface. If the engineer feels it necessary, another fine spray of water may be applied just before placing the base course.

**600.3.5 Construction** - Clause 600.1.5. shall apply.

**600.3.6 Trial mix** - Using the specified cement content and proportioned aggregates, the contractor shall make trial mixes at water contents ranging from 5 per cent to 7 per cent by weight of dry materials at 0.5 per cent intervals using an aggregate /cement ration of not greater than 15.0. Optimum moisture and density shall be established by preparing cubes with varying moisture contents. The compaction of mould shall be done in three layers as explained in clause 900.3.5.2.1. The optimum moisture content determined normally gives an indication about the moisture content which after minor adjustment may provide satisfactory mix which could be rolled.

After determining the moisture content from the above trial mix, a set of six beams and cubes shall be prepared for testing them on 3<sup>rd</sup> and 7<sup>th</sup> day. If the flexural strength achieved is lower than the desired strength, the above trial shall be repeated after increasing the cement content and adjusting the mix appropriately.

During the construction of trial length as per clause 600.3.7. minor modifications may have to be carried out to the moisture content of the mix. But such modified mix shall have to satisfy the flexural strength requirement. Flexural strength to be achieved shall be governing criteria for the design of mix.

**600.3.7 Trial length** - Clause 600.1.7. shall apply.

**600.3.8 Traffic** - No heavy commercial vehicles like trucks and buses shall be permitted on the rolled concrete base after its construction. Light vehicles may be, however, allowed after 7 days of its construction with prior approval of the engineer.

**600.3.9 Tolerances for surface Regularity, Level, Thickness and Strength**

The tolerances for surface regularity, level, thickness and strength shall conform to the requirements given in clause 903.5. Control of quality of materials and works shall be exercised by the engineer in accordance with Section 900.

**600.3.9 Tolerances for surface regularity, level, thickness and strength** - The tolerances for surface regularity, level, thickness and strength shall conform to the requirements given in Clause 903.5. Control of quality of materials and works shall be exercised by the engineer in accordance with section 900.

**600.3.10 Measurements for payment** - The unit of measurement for concrete and rolled concrete pavement shall be the cubic metre of concrete placed, based on the net plan areas for the specified thickness shown on the drawings as directed by the engineer.

**600.3.11 Rate** - The contract unit rate payable for rolled cement concrete for base course shall be payment in full for carrying out the required operations including full compensation for all labour, materials and equipment, mixing, transport, placing, compacting, finishing, curing, testing and incidentals to complete the work as per specifications, all royalties, fees, storage and rents where necessary and all leads and lifts.

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## **Annexure 600 A.21**

### **SECTION 600**

#### **CONCRETE SPECIFICATIONS FOR CONSTRUCTION OF CONCRETE ROADS (Extract of IRC - 15 -1981)**

##### **1. Scope**

1.1 This is intended to indicate what is considered to be good practice for the construction of cement concrete road pavements, including preparation of the subgrade and sub -base underneath these pavements. This does not however cover the requirements of fully mechanised constructions.

1.2 This section deals with various aspects of cement concrete road construction like materials, equipment, proportioning, measurement, handling of materials, and mixing, subgrade and sub -base preparation, formwork, joints, reinforcement, of concrete placing, finishing, curing etc. For greater elucidation of certain aspects such as properties and tests for concrete, arrangement of joints, reinforcement, load transfer devices, tie bars and concreting under cold weather supplementary notes have been added to this section, vide paras N.1 to N. 6. Provisions of this section shall apply unless required to be modified by special circumstances to take into account unusual conditions of traffic, subgrade, etc.

2. Some of the aspects of cement concrete roads are dealt with in greater detail in separate standards of IRC, vide list at Appendix -A. Reference to these standards is drawn in. the text where relevant.

##### **3. Materials**

**3.1.1. Ordinary and high strength ordinary portland cement** - This should comply with the requirements of IS - 269 -1976 Specification for Ordinary and Low -Heat Portland Cement (Third revision) or of IS; 8112 -1976 "Specification for High Strength Ordinary Portland Cement." Ordinary Portland Cement and High Strength Ordinary Portland Cement are most widely used for concrete pavements.

**3.1.2. Rapid hardening portland cement** - This should comply with the requirement of IS : 80411E-1976 "Emergency Specification for Rapid Hardening Portland Cement." In general, this cement would be used only where time is a critical factor and the road required to be opened to traffic at an earlier date than would be possible if Ordinary Portland Cement or High Strength Ordinary Portland Cement is used.

**3.1.3. Portland blast -furnace slag cement** - This should comply with the requirement of

IS: 455 -1967 "Specification for Portland Blast furnace Slag Cement (Second Revision).

**3.1.4 Portland pozzolana cement** -This should comply with the requirements of IS: 1489 -1976 "Specification for Portland Pozzolana Cement (Second Revision)".

## **3.2. Aggregates**

**3.2.1. General** - Aggregates should comply with IS - 383 -1970 "Specification for Coarse and Fine Aggregates from Natural Sources for Concrete (Second Revision)" with special reference to the additional requirements stipulated for use in road works excepting in the case of Los Angeles Abrasion Test limit. The Los Angeles Abrasion Test limits shall be not more than 35 per cent and 50 per cent for concrete wearing course and sub -base course respectively. In addition, the limits of deleterious material shall not exceed the requirements set out in IS - 515 -1959 "Specification for Natural and Manufactured Aggregates for Use in Mass Concrete." Weathered rock should not be used.

In order to make good concrete, it is important to avoid crushed aggregate of poor shape. Very angular, flaky, elongated or splintery aggregates give a harsh mix of low workability. Maximum size of aggregate should not exceed  $1/4^{\text{th}}$  of the pavement slab thickness. In case of pavements having reinforcement, maximum size of aggregate should also not exceed  $1/4^{\text{th}}$  of minimum clear spacing between reinforcing bars.

### **3.2.2. Coarse aggregates**

**Continuous grading** - Continuously graded coarse aggregate should be furnished in at least two separate sizes with separation at 20 mm I.S. sieve when combined material graded from 40 to 4.75 mm is specified, and at 25 mm I.S. sieve when combined material graded from 50 to 4.75 mm is specified.

**Gap grading** - Gap graded or single -sized coarse aggregate may be used, as an alternate aggregate to the continuously graded aggregate particularly where the grading of fine aggregate is fine to very fine, as stipulated in IRC : 59 -1976 'Tentative Guidelines for Design of Gap Graded Cement Concrete Mixes for Road Pavements." Gap grading may also become necessary when it is not economical to obtain materials to get continuously graded coarse aggregate as per standard or when it is found that omission of certain intermediate sizes is generally beneficial leading to easy admittance of the finer particles into coarser fractions through reduction in interference among the particles. **Thus, in some cases even poorly graded sand can be utilised by making adjustment in the coarse aggregate gradation to accommodate the available sand grading without particle interference.** In such cases the combination of coarse and fine aggregates suggested in Table I may be adopted -

Table 1. Suggested compatible gradation of coarse and fine aggregates for the purpose of gap -grading

Coarse aggregate (single sized)		Number of gaps	Smaller size coarse aggregate (single sized) (mm)	Fine aggregate (as per IS -383 – 1970, para 2.2.3) Sand zones
1	63 - 50	2	20 - 10	II or III
		3	10 – 4.75	III or IV
2	50 – 40	2	10 – 4.75	III or IV
		3	-	I or II
3	40 – 20	2	-	I or II
		3	-	II or III
4	20 - 10	2	-	II or III
		3	-	III or IV

For more details regarding design of gap graded cement concrete mixes, reference may be made to IRC - 59 -1976.

**3.2.3. Fine aggregate** - Fine aggregate shall preferably be natural sand. Crushed stone sand may also be used satisfactorily in concrete. The fine aggregate shall conform to IS : 383 -1970 excepting that in Grading Zone IV, the permissible percentage passing limits on 300 and 150 -micron sieves shall be 15 -55 per cent and 0 -20 per cent respectively instead of 15 -50 percent and 0 -15 per cent as stipulated in IS Specification. Crushed sand is usually more angular in shape than naturally occurring sand, and for this reason may tend to make the mix a little more harsh. In some cases, it may prove advantageous to use a mixture of naturally occurring sand and crushed stone sand if the former is not obtained in adequate supply or where its grading is poor. Bulking due to presence of moisture in the fine aggregate should be accounted for when volumetric batching is employed.

**3.3. Water** - Water used in mixing or curing of concrete shall be clean and free from injurious amounts of oil, salt, acid, vegetable matter or other substances harmful to the finished concrete. It shall meet the requirements stipulated in clause 4.3. of IS : 456 -1978 "Code of Practice for Plain and Reinforced Concrete (Second Revision)". Potable waters are generally considered satisfactory for mixing or curing.

### 3.4. Reinforcement

**3.4.1. Steel wire fabric** - This shall conform to the requirements of IS: 1566 -1967 "Specification for Hard -drawn Steel Wire Fabric for Concrete Reinforcement."



**3.4.2. Bar mats** - The steel in bar mats shall conform to the requirement of IS : 432 -1966 "Specification for Mild Steel and Medium Tensile Steel Bars and Hard -drawn Steel Wire for Concrete Reinforcement." The bars shall be of the size and spacing shown on the plans. All junctions of longitudinal and transverse bars shall be securely tied or welded together.

**3.5. Dowel and tie bars** - Dowel and tie bars shall be plain round steel bars conforming to the requirements of IS : 432 -1966.

**3.6. Premoulded joint filler** - Premoulded joint filler shall be of the thickness shown on the drawings within a tolerance of  $\pm 1.5$  mm. It shall be 25 mm less in depth than the thickness of the slab, within a tolerance of  $\pm 3$  mm and of the full width between road forms. Holes to accommodate dowel bars shall be accurately bored or punched out. The joint filler shall comply with the requirements of IS: 1838 -1961 "Specification for Preformed Fillers for Expansion Joint in Concrete, Non -extruding and Resilient Type (Bitumen -impregnated Fibre)."

**3.7. Joint sealing compound** - The sealing compound shall comply with the requirements of the IS: 1834 -1961 "Specification for Hot Applied Sealing Compounds for Joints in Concrete."

**3.8 Quality control tests on materials** – The quality control tests on the materials and the frequency of tests are given in IRC - Special Publication No.11 "Handbook of Quality Control for Construction of Roads and Runways (First Revision)" These are reproduced in Table 2 for ready reference

Table 2 Quality control tests on materials

Sl. No	Material	Test		Test Method	Minimum desirable frequencies
1	Cement	Physical and Chemical tests		IS: 269/445/1489/8112	Once for each source of supply and occasionally when called for in case of long and/or improper storage.
2	Coarse and fine aggregates	i)	Gradation	IS: 2386/ Pt.(I)	One test for 15 m <sup>3</sup> of each fraction of coarse and fine aggregate.
		ii)	Deleterious Constituents	IS: 2386/ Pt.(II)	-do-
		iii)	Moisture Content	IS: 2386/ Pt.(III)	Regularly as required subject to a minimum of one test per day for coarse aggregate and two tests per day for fine aggregate.
		iv)	Bulking of fine Aggregate (for Volume batching)	-do-	Once for each source for deriving the moisture content - bulking relationship.
3	Coarse Aggregate	i)	Los Angeles Abrasion value/ Aggregate impact test	IS: 2386/ (Pt.IV)	Once for each source of supply and subsequently when warranted by changes in the quality of aggregate.
		ii)	Soundness	IS: 2386/ (Pt. V)	As required
		iii)	Alkali-aggregate Reactivity	IS: 2386/ (Pt. VII)	-do-
4	Water		Chemical test	IS: 456	Once for approval of source of supply subsequently only in case of doubt.

#### 4. Proportioning of concrete

#### 4.1. Proportioning on the basis of strength

4.1.1. As the stresses induced in concrete pavements are mainly flexural, it is desirable that their design is based on the flexural strength of concrete. For economical design, the design value adopted for flexural strength of pavement concrete shall not be less than 40 kg/sq. cm at 28 days. The mix shall be so designed as to ensure the minimum structural strength in the field with the desired tolerance level. To achieve the desired minimum strength in the field, the mix in the laboratory shall be designed for somewhat higher strength, making due allowance for the type and extent of quality control feasible in the field.

With  $S$  = minimum strength of concrete in the field at 28 days,

$\bar{S}$  = average strength of concrete at 28 days for which the mix shall be designed in the laboratory,

$t$  = dimensionless factor for the desired tolerance level, and

$v$  = expected coefficient of variation (per cent) of field test samples, based on a knowledge of the type of control viz. 'very good', 'good' or 'fair', feasible at site,

$$S = \frac{\bar{S}}{\left(1 - \frac{tv}{100}\right)}$$

The values of tolerance level factor  $t$ , and coefficient of variation for normal paving concrete - are given in Table 3 for different degrees of quality control for general guidance in concrete mix design.

Table 3. Values of tolerance level factor 't' and coefficient of variation 'v' for different degree 'c' of quality control

Degree of quality control	Permissible tolerance	Tolerance factor t	Coefficient of variation v
'Very Good'	1 in 15	1.50	7%
'Good'	1 in 15	1.50	10%
'Fair'	1 in 10	1.28	15%

Note – **'Very Good' quality control** - Control with weigh -batching, use of graded aggregates, moisture determination of aggregates etc. Rigid and constant supervision by the quality control team.

**'Good' quality control** - Control with weigh -batching, use of graded aggregates moisture determination of aggregates etc. constant supervision by the quality control team.

**'Fair' quality control** - Control with volume batching for aggregates. Occasional checking of aggregate moisture. Occasional supervision by the quality control team.

4.1.2. The paving concrete mix should preferably be designed in the laboratory and controlled in the field on the basis of its flexural strength. Where this is not possible, correlation between flexural and compressive strengths should first be established on the basis of actual tests on additional samples made for the purpose at the time of designing the mix in the laboratory and quality control then exercised on the basis of compressive strength, so long as the materials and mix proportions remain substantially unaltered.

4.1.3. For design of cement concrete mixes guidance may be had from IRC - 44 -1976 "Tentative Guidelines for Cement Concrete Mix Design for Road Pavements" and IRC - 59 - 1976 "Tentative Guidelines for Design of Gap -graded Cement Concrete Mixes for Road Pavements."

4.1.4. Where a heavy duty wear -resistant concrete pavement is -desired, such as for maneuvering and storage areas of tracked vehicles or for anticipated concentrations of steel tyred traffic, concrete with minimum field compressive strength of  $450 \text{ kg/cm}^2$  at 28 days, shall be adopted for wearing course, the 28 days minimum flexural strength requirement in the field remaining  $50 \text{ kg/sq. cm}$ .

4.1.5. The minimum cement content for the mix corresponding to  $40 \text{ kg/cm}^2$  flexural strength in the field at 28 days shall not, however, be less than  $350 \text{ kg per m}^3$  of concrete and for mix corresponding to  $450 \text{ kg/cm}^2$  compressive strength in the field at 28 days shall be minimum of  $400 \text{ kg per m}^2$  of concrete.

**4.2. Approximate proportions** - The approximate proportions by weight (or by volume, only in unavoidable cases) necessary to produce concrete satisfying the above conditions using aggregates from the sources designated may be furnished in the tender documents, for guidance only, it being expressly understood that this information is only for the convenience of the bidder.

**4.3. Field mix** - After the award of the contract, the proportions, that is, the field mix, determined by the laboratory for the particular aggregates approved by the engineer shall govern. These proportions will be corrected and adjusted by the engineer to compensate for moisture content in the aggregates or fluctuations in the grading of coarse and fine aggregates at the time of use. Where fine aggregate is permitted to be measured volumetrically, due allowance should be made for its bulking.

**4.4. Water content and workability** - The water content per batch of concrete should be maintained constantly except for suitable allowances to be made for free moisture and absorption by aggregates determined from time to time during construction. Adjustments for workability shall be made by variations in the ratio of the coarse to fine aggregate or improving upon their grading without change in cement content or water -cement ratio. The slump of the concrete mix for pavements compacted by vibration should not be more than 25 mm, preferably between 0 and 12 mm, and that by manual compaction not more than 50 mm. No

price adjustment would be permissible for variations in the gradations of the aggregates or in the ratio of coarse to fine aggregates necessitated from adjustment at site.

4.5. More information about the desirable properties of paving concrete is given in Supplementary Notes, para N. 1.

## **5. Tools, equipment and appliances**

**5.1 General** - All tools, equipment and appliances necessary for proper preparation of subgrade, laying of sub -base and batching, mixing, placing, finishing and curing of concrete shall be at the project site in good working condition and shall have been inspected by the engineer before the paving operations are permitted to start. Throughout the construction of the project, the construction agency shall maintain all necessary tools, equipment and appliances in first class working condition to ensure proper execution of the work. Arrangements shall also be made for requisite number of stand -by units in the event of break -downs during construction.

### **5.2. List of tools, equipment and appliances**

5.2.1. A list of tools, equipment and appliances required for the different phases of concrete road construction is given below.

This list pertains to semi -mechanised type of construction only, as practised most in this country.

#### **(a) Subgrade and sub -base compaction -**

- (i) Compaction equipment (three wheeled or tandem roller, pneumatic roller, vibratory roller or sheep -foot roller)
- (ii) Watering devices (water lorries, bhisties/water carriers or watering cans),

#### **(b) Preparation of sub -bass for concreting and formwork**

- (i) Scratch templates or strike boards
- (ii) Bulk -heads
- (iii) Pick axes, shovels and spades
- (iv) Formwork and iron stakes

#### **(c) Concrete manufacture**

- (i) Shovels and spades
- (ii) Sieving screens
- (iii) Weigh batcher
- (iv) Aggregate measuring boxes (only where volume batching of aggregates is permitted as a special case)
- (v) Water pump
- (vi) Water measures
- (vii) Concrete mixer

#### **(d) Transportation, laying and compaction of concrete**

- (i) Wheel barrows/iron pans

- (ii) Wooden bridges
- (iii) Spades
- (iv) Concrete vibrators (both internal and screed board types)
- (v) Wooden hand tampers

**(e) Finishing operations - surface and joints**

- (i) Wooden bridges
- (ii) Floats (longitudinal and long -handled wooden floats)
- (iii) Templates
- (iv) Three -metre long straight edges including one master straight edge
- (v) Graduated wedge gauges
- (vi) Mild steel sections and blocks for making joint grooves
- (vii) Edging tools including double -edging tools
- (viii) Canvas belts
- (ix) Long handled brooms
- (x) Diamond cutter (when making saw -cut joints)
- (xi) Grinder (for grinding local high spots)

**(f) Curing**

- (i) Hessian cloth burlap or polyethylene sheeting
- (ii) Watering devices as in a (ii) (for ponding operation)

**(g) Cleaning and sealing of joints**

- (i) Iron raker
- (ii) Coir brush
- (iii) Cycle pump/pneumatic air blower
- (iv) Kerosene stove
- (v) Thermometer
- (vi) Transferring pot
- (vii) Painter's brush
- (viii) Pouring kettle
- (ix) Scraper

5.2.2. Specifications for different tools, equipment and appliances are given in IRC - 43 - 1972 "Recommended Practice for Tools, Equipment and Appliances for Concrete Pavement Construction." This document also gives a list of other small tools, equipment and appliances; minimum balanced set of tools, equipment and appliances; their routine maintenance and upkeep; and details of field laboratory equipment.

**6. Preparation of subgrade and sub -base**

**6.1 General** - The subgrade or sub -base for laying of paving concrete slabs shall comply with the following requirements -

- (1) that no soft spots are present in the subgrade or sub -base ;

(2) that the uniformly compacted subgrade or sub -base extends at least 300 mm on either side of the width to be concreted ;

(3) that the subgrade is properly drained ;

(4) that the minimum modulus of subgrade reaction obtained with a plate bearing test shall be  $5.5 \text{ kg/cm}^3$ .

The manner of achieving these requirements shall be determined depending upon the type of subgrade or sub -base on which concrete is to be laid, and the following requirements in respect of the various types shall be satisfactorily met. The construction procedures for subgrade and sub -bases should follow relevant IRC specifications, and quality control should be exercised as laid down in IRC -SP -11.

## **6.2. Subgrade**

6.2.1. Where the type of soil in the formation of the road is of a quality to ensure the requirements in the aforementioned para, no intermediate sub -base need be used. The top 150 mm layer of the formation shall be compacted at or slightly above the optimum moisture content to the exact profile shown in the drawing. It shall be checked for trueness by means of a scratch template (see IRC ; 43 -1972 for details) resting on the side forms and set to the exact profile of the base course. The template shall be drawn along the forms at right angles to the centre line of the road. Unevenness of the surface as indicated by the scratch points shall not exceed 12 mm in 3 m. The surface irregularities in excess of this shall be properly rectified and the surface rolled or tamped until it is smooth and firm. The subgrade shall be prepared and checked at least two days in advance of concreting.

6.2.2. Where no sub -base is considered necessary and concrete is laid directly on the prepared subgrade, the subgrade shall be in moist condition at the time the concrete is placed. If necessary, it should be saturated with water not less than 6 hours nor more than 20 hours in advance of placing concrete. If it becomes dry prior to the actual placing of the concrete, it shall be sprinkled with water taking care to see that no pools of water or soft patches are formed on the surface. It is desirable to lay a layer of water -proof paper whenever concrete is laid directly over soil subgrade. Where such a layer of waterproof paper is proposed to be placed between concrete and the subgrade, the moistening of the subgrade prior to placing of the concrete shall be omitted.

## **6.3. Sub -base**

6.3.1 Where the subgrade is of a type not satisfying the requirements of para 6.1, a sub -base layer should be provided before laying the concrete. The sub -base may be of granular material, stabilised soil or semi -rigid material as listed below -

### **(a) Granular material**

(i) one layer flat brick soling having joints filled with sand under one layer of water bound

macadam conforming to IRC - 19 -1977.

(ii) Two layers of water bound macadam.

(iii) Well -graded granular materials like natural gravel, crushed slag, crushed concrete, brick metal, laterite, kankar etc. conforming to IRC - 63 -1976.

(iv) Well -graded soil aggregate mixtures conforming to IRC - 63 -1976.

**(b) Stabilised soil**

Local soil or moorum stabilised with lime or lime -fly ash or cement, as appropriate to give a minimum soaked CBR of 50 after 7 days curing. For guidance as regards design of mixes with lime or cement, reference may be made to IRC - 51 and 50 respectively.

**(c) Semi -rigid material**

(i) Lime -burnt clay puzzolana concrete. The lime -puzzolana mixture should conform to L.P. 40 or L.P. 20 of IS : 4098 -1967. The 28 day compressive strength of the concrete should be in the range of 40 -60 km/cm<sup>2</sup>.

(ii) Lime -fly ash concrete conforming to IRC : 60 -1976.

(iii) Lean cement concrete or lean cement -fly ash concrete conforming to IRC: 74 -1979.

6.3.2. Thickness of sub -base should be 15 cm when the material used is of any of the types listed in paras 6.3.1. (a) and (b). This may, however, be reduced to 10 cm for semi -rigid materials in para 6.3.1(c). The sub -base should be constructed in accordance with the respective specification and the surface finished to the required lines, levels and cross - section.

6.3.3. Where the subgrade consists of heavy clay (L.L.>50) such as black cotton soil, the sub -base should be laid over a 15 cm thick blanket course consisting of non -plastic granular material like local sand) gravel, kankar, etc. or local soil stabilised with lime.

6.3.4. In water -logged areas and where the sub -grade soil is impregnated with deleterious salts such as sodium sulphate etc. in injurious amounts a capillary cut -off should be provided before constructing the sub -base, vide details given in para 6.4.

6.3.5. The sub -base or blanket course, as the case may be, shall be laid over a properly compacted subgrade to give uniform support.

6.3.6. The sub -base shall be in moist condition at the time the concrete is placed. There shall, however, be no pools of water or soft patches Formed on the sub -base surface. In case where a sand layer is placed between the sub -base and pavement concrete, a layer of water -proof paper shall be laid over the sand layer. No moistening of the sub -base shall be



done in this case.

#### 6.4. Capillary cut -off

6.4.1. As a result of migration of water by capillarity from the high water table, the soil immediately below the pavement gets more and more wet and this leads to gradual loss in its bearing value besides unequal support. Several measures such as depressing the sub - soil water table by drainage measures, raising of the embankment and provision of a capillary cut -off are available for mitigating this deficiency and should be investigated for arriving at the optimum solution. However, where deleterious salts in excess of the safe limits are present in the subgrade soil, a capillary cut -off should be provided in addition to other measures.

6.4.2. The capillary cut -off may be a layer of coarse or fine sand, graded gravel, bituminised material, or an impermeable membrane. Layer thicknesses recommended for different situations are given in Table 4.

Table 4 Recommended thickness of sand/graded gravel layer for capillary cut -off

Sl.No.	Situation	Thickness of layer cm		
		Coarse sand (mean dia 0.64 mm)	Fine sand (mean dia 0.18 mm)	Graded gravel (40 mm and down without fines)
1	Water table at the same level as the subgrade surface	15	45	15
2	Embankment about 0.6 – 1.0 m high	12	35	11
3	Embankment about 0.6 - 1.0 m high but with the top 15 cm subgrade layer being of sandy soil having PI of 5 or less and sand content not less than 50 percent	10	30	8

6.4.3. Cut -off with bituminised or other materials may be provided in any of the following ways

**(i) Bituminous impregnation using primer treatment** - 50 per cent straight run bitumen (80 -100) with 50 per cent high speed diesel oil or its equivalent in two applications of 1 kg sq.m. each, allowing the first application to penetrate before applying the second one, These applications should be given under the roadbed as well as onto the sides.

**(ii) Heavy -duty tar felt** - Enveloping sides and bottom of the roadbed with heavy -duty tar felt.

**(iii) Polyethylene envelope** - Enveloping sides and bottom of the roadbed with polyethylene sheets of at least 400 gauge.

**(iv) Bituminous stabilised soil** - Providing bituminous stabilised soil in a thickness of at least 4 -cm.

Note - Experience on the successful use of the above capillary cut -offs is, however, limited.

6.4.4. For more details about mitigating the adverse effects of high water table, reference may be made to IRC - 34 -1970 "Recommendations for Road Construction in Water logged Areas."

### **6.5 Frost affected areas**

6.5.1. In frost affected areas, the sub -base may consist of any of the specifications given in 6.3.1. (a), (b) or (c) excepting that in the case of the items 6.3.1. (b) and 6.3.1. (c), the compressive strength of the stabilised or semi -rigid material cured in wet condition shall be at least  $35 \text{ kg/cm}^2$  at 7 days. For moderate conditions, such as those prevailing in areas at an altitude of 3,000 m and below, the thickness of frost affected depth will be about 45 cm. For protection against frost, the balance between the frost depth (45 cm) and total pavement thickness should be made up with non -frost susceptible material.

6.5.2. For extreme conditions such as those prevailing in areas above an altitude of 3,000 m, the foundation may be designed individually for every location after determining the depth of frost.

6.5.3. The suggested criteria for the selection of non -frost susceptible materials are as follows -

(i) Graded gravel - Not more than 8 per cent passing 75 micron sieve. Plasticity index not more than 6. Liquid limit not more than 25,

(ii) Poorly graded sands, generally 100 per cent passing 4.75 mm sieve -  
Max. 10 per cent passing 75 micron sieve  
Max. 5 per cent passing 50 micron sieve

(iii) Fine uniform sand, generally 100 per cent passing 425 micron sieve -  
Max. 18 per cent passing 75 micron sieve  
Max. 8 per cent passing 50 micron sieve

### **6.6. Existing macadam sub -base**

6.6.1. When concrete pavement is laid over existing water bound macadam road, it shall be ensured that the existing macadam road constituting the sub -base extends over the required width and has a minimum thickness of 150 mm. Where the general unevenness of the surface varies by more than 25 mm from the required cross -section, the surface can be reconditioned after scarifying and adding suitable quantities of metal over the entire area including additional metal for correcting the camber and grade as required. Alternatively, depressions in the surface may be levelled up by using lean cement concrete or lime - pozzolana concrete or lime -fly ash concrete or lean cement -fly ash concrete as per para 6.3.1(c), properly compacted prior to laying of the concrete pavement slab, in addition to the depth that may be required for correction of the camber.

Where the width of the existing water bound macadam surface falls short of the width to be concreted by not more than 300 mm on either side and the condition of the surface is sound enough for receiving the paving concrete, the extra width may be made up by placing at least 100 mm depth of lean cement concrete or lime -puzzolana concrete or lime -fly ash concrete or lean cement -fly ash concrete as per para 6.3.1. (c) in trenches of required width at the sides of the existing metalling after taking care to see that the bottom of such trenches is well compacted by suitable tampers before placing of the new sub -base material. The correction to the unevenness of the surface and for camber shall follow the same lines as in the preceding paragraph.

Where the existing water bound macadam surface falls short of the width proposed to be concreted by more than 300 mm on either side, the sub -base shall be reconstructed by removing the entire material of the macadam and forming a fresh macadam surface of the required width by excavation and addition of new metal to the extent necessary over the entire width satisfying the requirements stated earlier.

**6.7 Existing black -topped surface** - Where concrete slabs are to be laid over existing black -topped surfaces, no special treatment is necessary where the surface extends over the required width and is worn uniformly under traffic. Otherwise, steps suggested in para 6.6. should be followed. Concrete shall not be laid on black -topped surfaces having soft spots caused by excessive bitumen or where thick premixed carpets have been rutted under traffic. In such cases the entire bituminous surfacing material shall be removed up to the top of the compacted macadam surface and the surface shall be prepared as detailed in para 6.6.

## **7. Forms**

**7.1. Steel forms** - All side forms shall be of mild steel unless use of wooden sections is specially permitted. The steel forms shall be mild steel channel sections of depth equal to the thickness of the pavement. The sections shall have a length of at least 3 m except on curves of less than 45 m radius, where shorter sections may be used. When set to grade and staked in place, the maximum deviation of the top surface of any section from a straight line shall not exceed 3 mm in the vertical plane and 5 mm in the horizontal plane. The

method of connection between sections shall be such that the joint formed shall be free from difference in level, play or movement in any direction. The use of bent, twisted or worn -out forms will not be permitted. At least three stake pockets for bracing pins or stakes shall be provided for each 3 m of form and the bracing and support must be ample to prevent springing of the forms under the pressure of concrete or the weight or thrust of machinery operating on the forms.

The supply of forms shall be sufficient to permit their remaining in place for 12 hours after the concrete has been placed, or longer if necessary in the opinion of the engineer.

**7.2 Wooden forms** - Wooden forms may be used only when specifically permitted in the drawing with the exception that their use is herein approved for all curves having radii of less than 45 m. Wooden forms shall be dressed on one side. They shall have minimum base width of 100 mm for slab thickness upto 200 mm and a minimum base width of 150 mm for slabs over 200 mm thick. Their depth shall be equal to the thickness of the pavement. These forms when used on straight shall have a minimum length of 3 m. Forms shall be held by stakes set at intervals not exceeding 2 m. Two stakes, one on each side, shall be placed at each joint. The forms shall be firmly nailed or secured to the side stakes, and securely braced at joints, where necessary, so that no movement will result from the pressure of the concrete or the impact of the tamper and during finishing work. Wooden forms shall be capped along the inside upper edge with 50 -mm angle iron well recessed and kept flush with the face of the wooden forms. The maximum deviation of the top surface of any section from a straight line shall not exceed the stipulations laid down in para 7.1.

**7.3 Setting of forms** - The forms shall be jointed neatly and shall be set with exactness to the required grade and alignment. Both before and after the forms are placed and set the subgrade or sub -base under the forms shall be thoroughly tamped in an approved manner. Sufficient rigidity shall be obtained to support the forms in such a position that during the entire operation of compacting and finishing of concrete they shall not at any time deviate more than 3 mm from a straight edge 3 m in length. Forms, which show a variation from the required rigidity or alignment and levels shown in the drawing, shall be reset or removed, as directed. The length and number of stakes shall be such as to maintain the forms at the correct line and grad -e. All forms shall be cleaned and oiled each time before they are used. Forms shall be set for about 200m ahead of the actual placing of concrete.

## **8. Joints**

**8.1 General** - The location and type of joints shall be as shown in the drawing. The edge of the slab at all joints shall be rounded off with an edging tool having a radius of  $6 \pm 1$ mm. The concrete along the face of all joints and around all tie bars and dowels shall be compacted with an internal vibrator inserted in the concrete and worked along the joint and around all tie bars and dowels to ensure a concrete free from honeycombing.

**8.2 Types of joints** - There are three general types of joints. These are -

**(i) Expansion joint** - Such joint provides the space into which pavement can expand thus relieving compressive stresses due to expansion and inhibiting any tendency towards buckling of concrete slabs.

**(ii) Contraction joint** - Such joint relieves tensile stresses in the concrete and prevents formation of irregular cracks due to restraint in free contraction of concrete. Contraction joints also relieve stresses due to warping.

**(iii) Warping joint** - Such joint relieves stresses due to warping. These are commonly used for longitudinal joints dividing the pavement into lanes.

In addition, construction joints are provided whenever construction operations require them. These are full depth joints and may belong to any of the above types.

All joints shall be carefully installed in accordance with the location and details given on the plans. The details of different types of joints are shown in Appendix B.

### **8.3. Transverse joints**

**8.3.1. General** - Transverse joints can be expansion, contraction or construction joints and shall be placed as indicated on the drawing. They shall make a right angle with the centre line of the pavement and surface of the sub-base/subgrade. Contraction and expansion joints shall be continuous from edge to edge of the pavement through all lanes constructed at the same or different times.

**8.3.2 Transverse expansion joints** - These shall extend over the entire width of the pavement. They shall be of the dimensions and spacing as shown on the drawing.

Dowel bars (see Supplementary Note N. 4) as per dimensions, location and spacing shown on the drawing are required at expansion joints to transfer wheel loads to the adjacent slab. For slabs of thickness less than 150 mm no dowel bars may be provided (IS: 6509 -1972). The premoulded expansion joint filler, a compressible material used to fill the gap between adjacent slabs at expansion joint shall conform to IS: 1838 -1961. The height of the filler board shall be such that its top is 25 mm below the surface of the pavement. The dowel bars shall be held accurately in position during the placement, compaction and finishing of concrete at and near the expansion joint. This and the protection of the joint groove during construction may be achieved by means of sufficiently strong bulkheads (as per IRC: 43 - 1972) with holes drilled along the centre line to accommodate the dowel bars and a mild steel section (as per IRC - 43 -1972) respectively. The latter shall be oiled or greased before placing in position to avoid bonding with concrete. The top and bottom edges of the bulkheads and mild steel section shall be shaped to correspond to the camber of the pavement at the joint. If considered convenient, two-piece split bulkheads may also be used. When dowel bars are provided, bulkheads shall be used in pairs, one at the joint location, and the other some distance away to hold the projecting ends of the dowel bars to

maintain their alignment.

For cases where dowel bars are not provided, one single bulkhead without holes will be adequate.

The bulkheads shall be securely staked in place at right angles to the centre line and surface of the pavement with sufficient stakes to hold them in the specified position.

After the concrete has sufficiently hardened the mild steel metal section shall be removed carefully without disturbing the edges. The edges shall then be rounded with an edging tool. For facilitating removal of the mild steel section as well as edging operation, the top of the section may be flared on both sides with the required curvature of a rounded edge.

Under no circumstances shall any concrete be left above the expansion joint filler or across the joint at any point. Any concrete spanning the ends of the joint next to the forms shall be carefully cut away after the forms are removed.

**8.3.3. Transverse contraction joints** - These shall be placed as shown on the drawing and shall be of the weakened plane or "dummy" groove type. They shall be constructed by forming in the surface of the slab a slot not less than 6 mm wide and having a depth equal to one-third to one-fourth the depth of the pavement at the thinnest part of its section. This slot may be formed in a manner approved by the engineer such as by pushing into the concrete a flat bar or the web of a "T" bar using a suitable vibratory device, removing the bar, and keeping the slot open. It shall be ensured that no spalling of concrete occurs while removing the bar. The edges of the joint shall be rounded with an edging tool before the concrete hardens.

**8.3.4 Transverse construction joints** - These shall be placed whenever placing of concrete is suspended for more than 30 minutes. Excepting in the case of emergency, construction shall always be suspended at the regular site of expansion or contraction joints. If the construction joint is located at the site of an expansion joint, regular expansion joint shall be provided; if at the site of a contraction joint or otherwise, the construction joint shall be of butt type with dowels. Procedure of construction of butt type joint is given in para 8.4 and details in Appendix -B.

At all construction joints, bulkhead shall be used to retain the concrete and care shall be taken in striking off and finishing the surface to the top face of the bulkhead. When work is resumed, the surface of concrete laid subsequently, shall conform to the grade and cross-section of previously laid pavement, and a straight edge 3m in length shall be used parallel to the centre line, to check any deviation in the surface of the two sections. Any deviation from the general surface in excess of 3 mm shall be corrected.

## **8.4. Longitudinal joints**

8.4.1. These shall be of the plain butt type and shall be formed by placing the concrete against the face of the slab concreted earlier. The face of the slab concreted earlier, shall be painted with bitumen before placing of fresh concrete.

8.4.2. Tie bars shall be used at longitudinal joints and they shall be of the dimensions and at spacings shown on the drawing. Tie bars shall be supported so as not to be displaced during construction operations. Tie bars shall be bonded in the slabs across longitudinal joints, and whilst casting the first slabs, they may be bent so that one end of them lies along the forms. After removal of the forms, bars shall be straightened so that they extend into the concrete placed on the other side of the joint.

8.5. For details about arrangement of the different types of joints, see Supplementary Note, N. 2.

## **9. Construction**

### **9.1. Storage and handling of cement**

9.1.1. Cement shall not be stored for a long time and should be used normally within six months of its date of receipt. Even during this period of storage it is essential that cement shall be protected from moisture by storing it in suitable sheds. Storage shed with a concrete floor laid on a well -drained foundation may be satisfactory. Cement in bags shall be stored on boards raised above the floor level for the purpose of ventilation, and the bags shall not touch the walls of the shed. Different consignments should be separately stacked and used in order in which they have been received. When bulk supply cement is used, special storage facilities such as covered hopper bins will be required.

9.1.2. Supply of cement should be co -ordinated with its consumption so that it is not stored right through the rainy season, when normally concreting is discontinued. Cement having lumps which have been caused due to improper storage or by pressure due to over -loading of bags shall not be considered for use unless these lumps can be easily powdered with pressure between fingers. Before such cement is used, representative sample containing also the lumps in fair proportion shall be taken and tested as per IS - 269 -1976, 8112 -1976, 1489 -1976, 455 -1967 or 8041E -1976 as the case may be, to fulfil the minimum requirements.

9.1.3. Owing to the slightly deliquescent nature of rapid -hardening cement special care should be taken in its storage and, in any case, it should not be stored for longer than three months.

### **9.2. Storage and handling of aggregates**

9.2.1. The location and preparation of sites, minimum size of stack and the methods adopted for dumping and stacking to prevent segregation of coarse and fine material shall be subject to the approval of the engineer. Aggregates from different sources and/or of different gradings shall not be stacked together. Each separate size of coarse aggregate

shall be stacked separately. The storing of aggregates upon the carriageway or shoulders shall not be permitted.

9.2.2. If aggregates are stored in conical stacks, segregation will be increased by the rolling of the coarser particles down the sides of the stacks. To avoid this, stacks should be built up in approximately horizontal layers. Dry fine aggregate segregates and gets blown away easily it may be helpful to moisten it.

9.2.3. To assist in controlling the water/cement ratio, large fluctuations in the moisture content of aggregates may be reduced by storing the bulk of the material well in advance of use. For this purpose, all washed aggregates shall be stacked for draining at least 12 hours before being batched. It is also a good practice to reserve the bottom 150 -300 mm or so of the stacks as a drainage layer. Where this cannot be done, the aggregates should not be placed on the ground. In such case, somewhat raised planks, metal sheets or concrete base should be provided and laid to slopes.

9.2.4. The aggregates shall be handled from the stacks and fed into the mixer in such a manner as to secure the stipulated grading of the material. Aggregates that have become mixed with earth or other foreign material shall not be used. They shall be washed clean before use.

### **9.3. Batching of materials**

9.3.1. All batching of materials shall be by weight. After determining the proportion of ingredients for the field mix, the fine aggregate and each separated size of coarse aggregate shall be proportioned by weight in an approved weigh -batching plant and placed into the hopper of the mixer along with the necessary quantity of cement. Cement shall be measured either by weight or by the bag as packed by the manufacturer. Where the bag measures cement, it would be necessary to sample -check the weight of the bags occasionally. All materials other than cement shall be calculated on the basis of one or more whole bags of cement taking the weight of cement as 1440 kg/m<sup>3</sup>. The engineer may permit the use of fractional bags of cement provided they are accurately weighed and are handled in a manner meeting with his approval. Water may be measured by volume. Where it is unavoidable, volume batching of aggregates may be permitted as a special case. It should, however, be borne in mind that weigh batching is definitely much more desirable than volume batching.

9.3.2. If batching by volume is permitted, as a special case, separate measuring boxes shall be provided for the different aggregates. The boxes shall be of strong construction provided with handles for convenient lifting and loading into the mixer. They shall be of such size that it should be possible to measure out the requisite quantity of aggregate per batch in whole box or by multiples thereof and capable of being lifted by two men. Each box shall be provided with a straight edge of required length for striking off after filling. If so directed by the engineer, improved facilities such as tipping boxes of accurate capacity working on run -



out rails arranged for direct delivery into the hopper of the mixer shall be provided by the construction agency. In volume batching, suitable allowance shall be made for the bulking of fine aggregate due to the presence of water. For this purpose the bulking shall be determined as per relevant Indian Standard Specification.

#### **9.4. Mixing**

**9.4.1 General** - The mixing of concrete shall be done in a batch mixer of approved type, which will ensure a uniform distribution of materials throughout the mass, so that the mix is uniform in colour and homogeneous. All concrete shall be mixed in quantities for immediate use.

The mixer shall be equipped with an approved water -measuring device capable of accurate measurement of water required per batch. The mixer shall preferably be equipped with a mechanically operated pump for filling the mixer tank.

The mixer, if so specified, shall be equipped with an approved timing device which will automatically lock the discharge lever during the full time of mixing and release it at the end of the mixing period; the device shall also be equipped with a bell, adjusted to ring each time the lock is released. If the timing device gets broken or out of order, the mixer will be permitted to be used while the same is being repaired, provided an approved time -piece equipped with minute and second hands is provided. Each batch shall be mixed for at least one and a half minutes.

Spilling of the materials at either end of the mixer shall be corrected by reducing the size of the batch and in no case shall the volume of the mixed material per batch exceed the manufacturers guaranteed capacity of the mixer. The type, size and number of mixers shall be so chosen as to provide the required output without overloading.

The mixing speed of the drum shall not be less than 15 revolutions per minute nor the peripheral speed of the drum greater than 60 m per minute.

The batch of cement, fine aggregate and coarse aggregate shall be fed into the mixer simultaneously with the water being introduced either at the same time or before the dry materials. The entire contents of the drum shall be discharged before any materials are placed therein for the succeeding batch.

The skip shall be so maintained and operated that each batch will be completely discharged into the mixing drum at the loading of the mixer. The mixer shall be cleaned at suitable intervals while in use.

Pick -up and throw -over blades in the drum of the mixer which are worn down 20 mm or more in depth shall be replaced with new blades.

**9.4.3. Retempering** - The retempering of concrete i.e. remixing with or without additional cement, aggregate or water shall not be permitted.

**9.5.1. Workability of concrete** - The workability of concrete shall be checked by performing "slump test" or "compacting factor test" in accordance with IS : 1199 -1959 "Method of Sampling and Analysis of Concrete." The frequency of testing shall be one test per 10 m3 of concrete and the permissible tolerances from the specified value for workability shall be -

Compacting factor  $\pm 0.03$

**9.5.2. Strength of concrete** - The strength of concrete shall be determined either by compressive or flexural strength tests (preferably the latter, since concrete pavements are designed on the basis of flexural strength of concrete) depending on the facilities available. For this purpose, during the progress of the work, cube/beam samples shall be cast for testing at 7 and 28 days. Sampling and testing shall be done in accordance with IS - 1199 - 1959 "Method of Sampling and Analysis of Concrete" and IS - 516 -1959 "Method of Test for Strength of Concrete" respectively. The minimum frequency of samples shall be 3 cube/beam samples for each age of 7 and 28 days for every 30 m<sup>3</sup> of concrete. For details about determination of concrete strength, reference may be made to para 10.2.

On a paving job, the strength of concrete should be continuously monitored to ensure that the design strength is achieved. In certain cases, because of change in the source of cement or control or climatic factors, the strength may show some variations, which would require re-designing of the mix. However, where the variations are not large, the mix proportions could be adjusted in the field through a simple procedure explained in Appendix -C obviating the need for redesigning.

**9.6. Transporting and placing of concrete** - The concrete shall be mixed in quantities required for immediate use and shall be deposited on the subgrade/sub-base to the required depth and width of the pavement section, in successive batches and in continuous operation without the use of intermediate forms or bulk-headers between joints. Care shall be taken to see that no segregation of materials results whilst the concrete is being transported from the mixer to the place where it is deposited. The usual method of transport of concrete in India is in pans as head loads or in small wheel barrows. The spreading shall be as uniform as possible to avoid rehandling of the concrete. Where, however, a certain amount

of re -distribution is necessary, it shall be done with shovels and not with rakes. While being placed, the concrete shall be rodded with suitable tools for slab thicknesses of 12.5 cm and less so that formation of voids or honeycomb pockets is prevented. The concrete shall be particularly well placed and tapped against the forms and along all joints, For higher thicknesses an internal vibrator shall be employed in lieu of rodding of the concrete. To effect adequate compaction, the concrete shall be placed with appropriate surcharge over the final slab thickness. The amount of surcharge will depend on the mode of placement of concrete and shall be determined by trial. In general, the required surcharge is about 20 per cent of the required slab thickness. Any portion of the batch of concrete that becomes segregated while depositing it on subgrade shall be thoroughly mixed with the main body of the batch during the process of spreading. In case of unavoidable interruption, a full depth transverse joint shall be made at the point of stoppage of work provided the section on which the work has been suspended is about 2 to 3 m long.

In placing of concrete for two course construction, necessitated by either positioning of the reinforcement, a richer mix for the wearing surface, or when thickness of the concrete is beyond 20 cm, the bottom layer of concrete shall be struck off to the required levels by a vibrating screed working on the side forms with notches corresponding to the depth of the top course of concrete. The vibrating screed should have a vibrating unit mounted on it similar to that of the screed used for compaction of the final surface of concrete. The time lag between laying of the two courses shall not exceed the initial setting time of cement.

**9.7 Water -proof paper** - The water -proof paper, when necessary (see para 6.2.) shall be laid by unrolling the roll prior to the placement of concrete. The paper shall be unrolled with an overlap of not less than 10 cm.

## **9.8 Placement of steel**

**9.8.1 Reinforcement** - Reinforcing steel shall be free from dirt, scale or other foreign matter and rust of such degree or development as to impair bond of the steel with the concrete. The width of fabric sheets or bar mats shall be such that when properly placed into the work the extreme longitudinal bars or wires of the sheets or mats will be located not less than 50 mm and not more than 100 mm from the edges of the slab. Except for dummy joints, the length of fabric sheets or bar mats shall be such that when properly placed into the work, the reinforcement will be clear of transverse joints by not less than 50 mm and not more than 100 mm as measured from the centre of the Joint to the ends of longitudinal bars or wires of the sheet or mat.

While overlapping the sheets or mats in either direction, the overlap shall be at least equal to the spacing between the bars or wires in the respective direction or 40 times the diameter of the bar or wire, whichever is more.

Whilst using reinforcement in one layer, the concrete shall be placed in two stages. The initial layer shall be uniformly struck off to a depth corresponding to the reinforcement shown

in the drawings and lightly compacted by a screed to obtain uniform levels. The reinforcing fabric sheet or bar mat shall then be placed on the compacted layer of concrete and remaining depth shall be filled in with concrete thereafter.

In doing this operation, the initial layer of concrete shall be struck off to the entire width of the slabs and of sufficient length to permit sheet or mat of reinforcement to be laid full length without further manipulations of the reinforcement. Displacement of the reinforcement during concreting operations shall be prevented.

Details about the types, design and location of reinforcement are given in Supplementary Note, N. 3.

**9.8.2. Load transfer devices - dowels** - Transverse expansion joints shall be equipped with dowels of the dimension and at the spacing and location indicated on the drawing. They shall be firmly supported in place, accurately aligned parallel to the subgrade/sub-base, parallel to each other and parallel to the centre line of the pavement, by means of appropriate dowel supports. The dowel supports shall ensure that the dowels are not displaced during construction. The permissible tolerances in dowel bar alignment in both vertical and horizontal directions shall be  $\pm 1$  mm in 100 mm for dowels of 20 mm and smaller diameters and  $\pm 0.5$  mm in 100 mm for dowels of diameter greater than 20 mm. One-half of each dowel shall be painted with a thin film of bitumen and equipped with a tight fitting metal sleeve of the dimensions shown on the drawing to provide space for the dowel when pavement expands and the joint closes. This sleeve shall be partly filled with cotton waste to prevent it being pushed too far on the dowel during construction

These sleeves are not required on dowels, if used, in dummy contraction or construction joints.

Design of dowels is discussed in Supplementary Note, N. 4.

**9.8.3. Tie bars** - Tie bars provided in longitudinal joints of plain butt type to prevent opening of such joints shall be bonded to the adjacent slabs on both sides of the longitudinal joint. They are installed by providing appropriate (drilled) holes in the side forms depending on the size and spacing of bars. They are bent aside temporarily to avoid obstruction to construction traffic and straightened later at the time of laying of slab in the adjacent lane.

Design of tie bars is explained in Supplementary Note, N. 5.

## **9.9. Compaction and finishing**

**9.9.1. Compaction** - The pavement shall be compacted either by means of a power - driven paver -cum -finisher or by a vibrating screed along with internal vibrators where the slab thickness is more than 12.5 cm. For lesser thicknesses vibrating screed may be supplemented with manual rodding. For areas where the width of the slab is very small as at the corner of street junctions, etc. compaction with wooden hand tampers may be adopted subject to the approval of the engineer. In no case, however, hand compaction shall be permitted for slab thicknesses beyond 10 cm. All compaction shall be done in accordance with the following requirements -

**(i) Paver -cum -finisher of standard make or standard vibrating screed and internal vibrators shall be used for compaction** - The vibrating screed shall rest on side forms. It shall be lowered vertically on to the concrete surface, evenly spread to the appropriate level above the base to provide the required surcharge for compaction; allowed to remain in position for a few seconds until compaction is complete, then lifted vertically and lowered on to the adjacent strip of un -compacted concrete. The amplitude of vibration of the screed shall not be less than 1.5 mm and the speed of travel not more than 0.6 m per minute. The screed shall again be taken slowly over the surface, sliding with its axis slightly tilted away from the direction of sliding and the operation repeated until the required dense, close knit textured surface is obtained. Compaction of concrete slabs upto 12.5 cm thickness may be done by means of vibrating screed alone, while for thicknesses greater than 12.5 cm both internal vibrators and vibrating screeds shall be used. Even in the case of slabs of lower thickness, internal vibrators may be used with advantage for compacting the slab corners and edges. The working of the vibrators shall be regularly checked and stand -bys shall always be maintained for emergency use.

**(ii) Where hand tamping is permitted as a special case -**

(a) Concrete with surcharge, as soon as placed, shall be struck off uniformly and screeded, to such level above the base that when compacted and finished, the pavement shall conform to the grade and cross -section indicated by the plans. The entire surface shall then be

tamped and the tamping operation continued until a close knit dense surface is obtained.

(b) The tamper shall rest on the side forms and shall be drawn ahead with a sawing motion, in combination with a series of lifts and drops alternating with lateral shifts, the aim of this operation being compaction and screeding to the approximate level required. Subsequent tamping should advance about 75 mm at a time in the direction in which the work is proceeding, and in the final stages tamping should be closer, about 12 mm at a time until a level and dense surface is obtained.

(iii) Segregated particles of coarse aggregate which collect in front of the tamper or screed shall be thrown outside the forms or thoroughly mixed by hand with the uncompacted mass of concrete already placed. Under no circumstances shall such segregate particles be carried forward and pushed on to the base in front of the mass.

(iv) Compaction by tamping or screeding shall be carried on till the mortar in the mix just works up to the surface. Care shall be exercised and the operation of tamping so controlled as to prevent an excess of mortar and water from being worked on to the top. Repeated operation other than to secure the necessary compaction and to eliminate voids shall be avoided.

(v) Immediately after the tamping or screeding has been completed and before the concrete has hardened, i.e. while the concrete is still in a plastic stage, the surface shall be inspected for irregularities with a profile checking template and any needed correction made by adding or removing concrete followed by further compaction and finishing.

**9.9.2. Floating** - As soon as practicable after the concrete has been compacted, its surface shall be smoothened by means of a longitudinal float, operated from a foot -bridge. The longitudinal float shall be worked with a sawing motion, while held in a floating position parallel to the carriageway centre line and passed gradually from one side of the pavement to the other. Movements ahead along the centre line of the carriageway shall be in successive advances of not more than one half the length of the float.

**9.9.3. Straight-edging** - After the longitudinal floating has been completed and excess water has disappeared, but while the concrete is still plastic, the slab surface shall be tested for trueness with a 3 m straight edge. The straight edge shall be held in successive positions parallel to the road centre line in contact with the surface and the whole area gone over from one side of the slab to the other. Advance along the road shall be in successive stages of not more than one -half length of the straight edge. Any area of depression found shall be scooped to a depth of 4 -5 cm, filled immediately with freshly mixed concrete, struck, compacted, and refinished. High areas shall be cut down and refinished. The straight edging and refloating shall continue until the entire surface is found to be free from observable departures from the straight edge and the slab has the required grade and camber.

The slab surface shall be retested for trueness, before the concrete begins to set, with the 3 m long master straight edge and the graduated wedge gauge.

The straight edge shall be placed on the surface in successive positions, parallel to the carriageway centre line. Irregularities shall be measured with the help of the wedge gauge moved transversely at various points until it touches both the straight edge and the concrete surface.

At any point tested the concrete shall not show a departure greater than 3 mm from the true surface. If at any place the departure exceeds this value not more than 3 passes of the vibrating screed shall be allowed and the surface tested again in the specified manner. If the irregularity still exceeds the limit aforesaid, the concrete shall be removed to a depth of 50 mm or upto the top surface of the reinforcement, if any. The area of concrete to be removed shall be demarcated by the length of the straight edge in the position of measurement across the full width of the slab. Where the point of measurement in default is less than 4.5m from the nearest transverse expansion joint, the whole area upto the joint shall be removed to the required depth. The concrete so removed shall not be re-used in the carriageway. Fresh concrete shall be placed, compacted and finished in the manner already described in these specifications and shall again be subject to test for accuracy of finish.

The foregoing procedure shall be adopted at each shifting of the straight edge and the whole area shall be gone over from one side of the slab to the other. The straight edge shall advance Longitudinally in successive stages of not more than one -half the length of the straight edge.

No extra payment shall be made for the removal of the rejected concrete and or laying fresh concrete.

Although the concrete may be removed immediately following measurement of the irregularity and while it is still wet, this shall not mean any waiver from complying with the requirements of this clause, if for any reason the concrete to be removed has already hardened.

After straight edging of the surface, it shall be finished by belting and brooming in the manner described in para 9.9.4. and 9.9.5.

**9.9.4. Belting** - Just before the concrete becomes non -plastic, the surface shall be belted with a two-ply canvas belt having suitable handles to permit controlled uniform manipulation. The belt conforming to the stipulations laid down in IRC - 43 -1972 shall be operated with short strokes transverse to the carriageway centre line and with a rapid advance parallel to the centre line.

**9.9.5. Brooming** - After belting and as soon as surplus water if any has risen to the

surface, the pavement shall be given a broom finish with an approved long handled steel or fibre broom conforming to the stipulations laid down in IRC - 43 -1972. The broom shall be pulled gently over the surface of the pavement from edge to edge. Adjacent strokes shall be slightly overlapped. Brooming shall be perpendicular to the centre line of the pavement and so executed that the corrugations thus produced will be uniform in character and width, and about 5mm deep. Brooming shall be completed before the concrete reaches such a stage that the surface is likely to be torn or unduly roughened by the operation. The broomed surface shall be free from porous or rough spots, irregularities, depressions and small pockets, such as may be caused by accidentally disturbing the particles of coarse aggregate embedded near the surface.

**9.9.6. Edging** - After belting and/or brooming have been completed, but before the concrete has taken its initial set, the edges of the slab shall be carefully finished with an edging tool of 6 mm radius and conforming to the requirements laid down in IRC - 43 -1972 so as to leave the pavement edges smooth and true to line.

**9.10. Curing of concrete** - Immediately after the finishing operations have been completed the entire surface of the newly laid concrete shall be covered against rapid drying, and cured. Failure to provide sufficient cover material of the stipulated type or inadequate supplies of water for curing shall be adequate cause for immediate suspension of concreting operations.

**9.10.1. Initial curing** - After completion of the finishing operations, the surface of the pavement shall be entirely covered with wet hessian cloth, burlap or jute mats. The coverings used shall be of such length (or width) that when laid will extend at least 500 mm beyond the edges of the slab, shall be so placed that the entire surface and both the edges of the slab are completely covered. They shall be placed as soon as the concrete has set sufficiently to prevent marring of the surface. Prior to their being placed, the coverings shall be thoroughly wetted with water and placed with the wettest side down. They shall be so weighed down as to cause them to remain in intimate contact with the surface covered. They shall be maintained fully wetted and in position for 24 hours after the concrete has been placed, or until the concrete is sufficiently hard to be walked upon without suffering any damage. To maintain the coverings wet, water shall be gently sprayed so as to avoid damage to the fresh concrete. If it becomes necessary to remove the coverings for any reason, the concrete slab shall not be kept exposed for a period of more than half an hour.

Worn coverings or coverings with holes shall not be permitted. Coverings reclaimed from previous use other than curing concrete shall be thoroughly washed prior to use for curing purposes, if the covering is furnished in strips, the strips shall be laid to overlap at least 150 mm.

Covering shall be placed from suitable wooden bridges (IRC -43 -1972). Walking on freshly laid concrete to facilitate placing coverings will not be permitted.



**9.10.2. Final curing** - Upon the removal of the covering the slab shall be thoroughly wetted and then cured by one of the following methods of final curing -

**(a) Curing with wet earth** - Exposed edges of the slab shall be banked with a substantial berm of earth. Upon the slab shall then be laid a system of transverse and longitudinal dykes of clay about 50 mm high, covered with a blanket of sandy soil free from stones to prevent the drying up and cracking of clay. The rest of the slab shall then be covered with sufficient sandy soil so as to produce a blanket of earth not less than 40 mm depth after wetting. The earth covering shall be thoroughly wetted while it is being placed on the surface and against the sides of the slab and kept thoroughly saturated with water for 14 days and thoroughly wetted down during the morning of the 15th day and shall thereafter remain in place until the concrete has attained the required strength and permission is given to open the pavement to traffic. When such permission is granted, the covering shall be removed and the pavement swept clean. If the earth covering becomes displaced during the curing period, it shall be replaced to the original depth and re-saturated,

**(b) Impervious membrane method** - The membrane shall consist of a practically colourless impervious liquid of a type approved by the engineer. The use of any membrane material which would impart a slippery surface to the pavement or alter its natural colour will not be permitted. Liquid shall be applied under pressure with a spray nozzle in such a manner as to cover the entire surface with a uniform film, and shall be of such character that it will harden within 30 minutes after application. The amount of liquid applied shall be ample to seal the surface of the pavement thoroughly. The liquid shall be applied immediately after the finishing of the surface and before the cement has set, or, if the pavement is first covered with burlap or hessian cloth or the like, it may be applied upon their removal.

The impervious coating used for membrane curing shall be such that when applied to the surface of test slabs made of cement sand mortar in the manner prescribed for the use of the materials in the field, the mortar shall retain at least 90 per cent of the mixing water when exposed for 144 hours to temperatures between 32 to 38°C at a relative humidity of 30 per cent to 50 per cent.

The mortar test slab used shall be composed of one part cement, 1.71 parts fine aggregate and 0.346 parts of water, by weight. The slab shall be cast in a non-absorbent watertight mould, and shall remain in the mould throughout the test. The slab shall be approximately 400 mm long by 400 mm wide by 50 mm deep. The coating shall be applied to the exposed surface of the slab within 2 hours of the time the slab is cast.

Materials for use as impervious coatings will be approved by the engineer on the basis of test outlined above. The rate of application of such coatings will be prescribed by the engineer on the basis of the same tests.

This method of curing may be found suitable in locations where there is scarcity of water and in ghat sections.

**9.11. Final surface test** - The final surface test shall be made after the curing period and after the removal of the material used for curing. The surface shall be of correct alignment, grade and contour specified. Any spots higher than 3 mm and not higher than 6 mm above the correct surface, as shown by the 3.0 m straight edge and the wedge gauge, used in the manner prescribed above, shall be ground down with an approved grinding tool to the required level. When deviation exceeds the foregoing limits, the slab shall be removed to the full depth and replaced. The area of pavement to be removed and replaced shall be that represented by the nearest transverse joints, adjacent to the deviation, across the full width of the slab.

**9.12. Removing forms** - Forms shall not be removed from freshly placed concrete until it has set, or at least 12 hours, whichever is later. They shall be carefully removed in such a manner that no damage is done to the edges of the pavement. After the forms have been removed, the slab edges shall be cleaned and any limited honey-combed areas pointed up with 1 -2 cement sand mortar, after which the sides of the slab shall be covered with earth to the level of the top of the slab for final curing (para 9.10.2). Slabs with excessive honey-combing as a result of inadequate compaction shall be removed between nearest transverse joints.

**9.13. Concreting during monsoon months** - When concrete is being placed during monsoon months and when it may be expected to rain, sufficient supply of tarpaulins or other waterproof cloth shall be provided along the line of work. Any time when it rains, all freshly laid concrete, which has not been covered for curing purposes, shall be adequately protected by means of tarpaulins or other waterproof cloth. Any concrete damaged by rain shall be removed and replaced.

**9.14. Concreting in hot weather** - As placing of concrete in air temperatures above 40°C, or above 35°C combined with relative humidity below 25 percent and/or wind velocity higher than 10 km/hour, is attended with defects like loss of workability through accelerated setting, formation of plastic shrinkage cracks, etc., it is recommended that unless adequate precautions are taken, no concreting shall be done in conditions more severe than the above. The procedures recommended for adoption in case of hot weather concreting is given in IRC - 61 -1976 "Tentative Guidelines for the Construction of Cement Concrete Pavements in Hot Weather." Brief details of the procedure are given below -

Aggregates, cement and water shall be protected from the direct sun and mixing operations shall also be carried out in shade. In addition portable shelters shall be provided to protect the concrete during placing and finishing operations. This may be in the form of gable frames to cover the full length of the concrete pavement laid in a day. The surfaces of the

formwork and subgrade coming in contact with concrete shall be moistened prior to placing of the concrete to prevent absorption of mixing water. Since the setting time of concrete is considerably reduced under such temperatures, labour force shall be reinforced to minimise the time between mixing and placing of concrete. The protective cover shall be adequate to exclude exposure of the concrete directly to the sun and also eliminate contact with drying winds. Prior to removal of the portable shelters, the hardened concrete shall be covered with wet hessian or burlap or the like followed by one of the usual methods of curing like ponding, etc. In addition, the moist curing period shall be extended to 4 weeks.

**9.15. Concreting in cold weather** - Except by specific written authorization from the engineer, concreting shall not be continued when a descending air temperature in the shade and away from artificial heat drops below 4°C, nor shall concreting be resumed until an ascending air temperature in the shade and away from artificial heat reaches 4°C.

When specific written authorisation is granted to permit concreting at temperatures below that specified above, equipment to heat the aggregates and water shall have to be provided. In addition, use of calcium chloride as an accelerator when so indicated may be permitted. The amount of calcium chloride solution used shall not exceed about 2.3 litres per bag (50 kg nett) of cement and this solution shall be considered as a part of the mixing water. This solution shall be prepared by dissolving 45 kg of granulated or flaked calcium chloride in about 95 litres of water. Normally ordinary Portland cement as per IS - 269 -1976 alone shall be used when calcium chloride is employed as an additive. Also it is recommended that when calcium chloride is proposed to be used, there should be no steel reinforcement in the concrete pavement.

Concrete heating equipment capable of producing concrete that will have temperature of at least 15°C and not exceeding 32°C at the time of placing it between the forms shall be provided. The aggregates shall be heated prior to being loaded into the concrete mixer. The equipment used shall beat the mass uniformly and shall preclude the possible occurrence of overheated zones which might affect the concrete properties. Water used for mixing shall not be heated beyond 66°C. Material containing frost, ice, snow or lumps of hardened mass shall not be used. Heating methods, which alter or prevent the entrainment of the required amount of air in the concrete shall not be adopted. During placement of concrete, tarpaulin covers or other readily removable coverings should closely follow the placing of concrete, so that only a few metres of the finished slab are exposed to the outside air at any one time. The coverings may be so arranged that heated air, where provided, could be freely circulated on top of the pavement. The coverings may be further covered by layers of straw or other insulating materials, no sooner the wet concrete is strong enough to take their load.

When concrete is being placed in cold weather and the air temperature is expected to fall below 2°C, the air surrounding the concrete shall be maintained at a temperature of 15°C for at least 3 days and not less than 4°C for a period of not less than 7 days.

Any concrete damaged by frost action shall be removed and replaced.

Under no circumstances shall the concreting operations continue when the air temperature is less than  $-7^{\circ}\text{C}$ .

For more details about concreting in cold weather, see Supplementary Note, N.6.

**9.16. Work on gradients** - The progress on gradient of all operations of placing, compacting and finishing of concrete should proceed from the lower to the higher reaches. The concrete mix shall be stiffer than that used on level reaches.

**9.17. Protection of concrete** - Suitable barricades shall be erected and maintained and watchmen employed to exclude traffic from the newly constructed pavement for the period herein prescribed, and these barriers shall be so arranged as not in any way to interfere with or impede traffic on any lane intended to be kept open and necessary signs and lights shall be maintained clearly indicating any lanes open to the traffic. Where, as shown on the plans or indicated in the special provisions, it is necessary to provide for traffic across the pavement, suitable and substantial crossings to bridge over the concrete shall have to be provided. Such crossings, as constructed, shall be adequate for the traffic and approved by the engineer.

Any part of the pavement damaged by traffic or other causes occurring prior to its final acceptance shall be repaired or replaced in a manner satisfactory to the engineer. The pavement shall be protected against all traffic usage including that of construction -traffic.

**9.18. Sealing of joints** - After the curing period is over and before the pavement is opened to traffic, the temporary seal and all other intruded materials in the transverse expansion and contraction joints as well as longitudinal joints shall be removed completely and the groove; filled with the approved joint sealing compound as per IRC - 57 -1974 "Recommended Practice for Sealing of Joints in Concrete Pavements". The joint opening shall be thoroughly cleared of all foreign matter before the primer followed by sealing material is placed. If necessary, the foreign matter shall be blown out by compressed air pressure. All contact faces of the joint shall be cleaned with a wire brush to remove loose material and shall be surface dried before the primer is applied.

The edges of joints shall be primed with primer, generally a thin bituminous paint, which shall be allowed to dry before the sealing compound is applied. The primer shall be applied with a brush.

One typical composition of the primer is as follows -

	Percentage by weight
i) Bitumen (200 -penetration grade)	66 (blended hot)
ii) Light Creosote Oil	14 (blended hot or cold)
iii) Solvent Naphtha	20 (blended cold)

Note - The bitumen (I) shall be melted and fluxed with the oil (ii). When cold, solvent naphtha (iii), shall be added. Bituminous emulsions shall not be used as primers.

Care shall be taken to ensure that the sealing compound is not heated above 200°C and the temperature does not exceed 180°C for long periods (or other temperatures specified by the manufacturer of the compound).

Sealing compound shall be poured into the joint opening in such a manner that the material will not be spilled on the exposed surface of the concrete. Equipment recommended for the purpose in IRC: 43 -1972 may be found helpful. Any excess filler on the surface of the concrete pavement shall be removed immediately and the pavement surface cleaned.

When required to prevent tackiness or pick -up of the seal under traffic, the exposed surfaces of the sealing compound shall be dusted with dry hydrated lime. Other methods of preventing pick -up of seal under traffic may be used when approved by the engineer.

The line of separation between adjacent slabs of concrete, when the pavement is constructed in lanes or strips shall be cleaned and painted with 200 -penetration grade bitumen.

**9.19. Opening to traffic** - In general, traffic shall be excluded from the newly constructed pavement for a period of 28 days where Ordinary Portland Cement, Portland Blast Furnace Slag Cement and Portland Pozzolana Cement are used, or for a period of 7 days where Rapid Hardening Cement is used. In all cases, before the pavement is opened to traffic it shall be cleaned and the joints shall be sealed as per para 9.18.

## **10. Basis of payment**

**10.1. Tolerance in pavement thickness** - The pavement shall be constructed strictly in accordance with the thickness shown on the drawing. Prior to placing of concrete, approval of the levels of the subgrade or sub -base shall be obtained from the engineer or his representative for ensuring this requirement. In case of disputes arising from non - compliance of the above, the checks on pavement thickness may be insisted upon by cutting of cores at the locations to be decided by the engineer. After the cores are taken out, the thickness of the pavement shall be determined by average calipers measurement. The following procedures relating to replacement of the faulty pavement and adjustment of price shall then govern.

For pavement slab, the average thickness of which, determined as hereinafter provided is equal within 3 mm to the thickness required by the typical cross -section shown on the drawing, the contract unit price shall be used in payment.

For pavement slab, the average thickness of which determined as hereinafter provided, is

less than the thickness shown on the drawing by more than 3mm, but by less than 12 mm, an adjusted unit price shall be used in payment, which price shall bear the same ratio to the contract unit price as the square of the actual average thickness of the slab bears to the square of the thickness specified on the drawings.

No additional payment over the unit contract price bid will be made for any slab, should the average thickness of the pavement determined as hereinafter provided, exceed the thickness shown on the drawings.

Payment will not be made for slab, which is found deficient in thickness by 12 mm or more. Such pavement slabs shall be removed and replaced by slabs of the specified thickness. When the measurement of any core indicates that the slab is deficient in thickness by 12 mm or more, determination shall be made of the actual thickness of transverse sections of the slab at 7.50 m intervals set off along the centre line of the road in each direction from the affected location until, in each direction, a transverse section of the slab is found which is not deficient in thickness by as much as 12 mm. The area of the slab for which no payment will be made shall be the product of the full width of the slab or strip of pavement multiplied by the sum of the distances in each direction from affected location along the centre line of the road to the transverse sections found not deficient in thickness by as much as 12 mm. The number of cores taken should be sufficient to fairly indicate the actual thickness of pavement.

The cost of extraction of the cores in the case of deficient thickness shall be borne exclusively by the contracting agency. Where, however, a part of the cores complies with the thickness requirements, the cost shall be borne pro -rata by the department and the contracting agency in the ratio of the number of cores of deficient thickness to the number of cores of adequate thickness. Where all the cores comply with the thickness requirements, then the entire cost shall be borne by the department.

**10.2. Determination of concrete strength** - The strength of concrete shall be determined either by flexural or crushing strength tests depending on facilities available at the ages of 7 and 28 days with at least three specimens for testing at each age for every 30cu.m. of concrete, at a place to be designated by the engineer. During transportation, the specimens shall be embedded in straw, hessian or other acceptable material in a manner meeting with the approval of the engineer so as to prevent sudden impacts during hauling and handling which might cause fractures.

A progress chart indicating the strength values of individual sets of specimens shall be maintained. The statistical parameters, viz. mean strength and upper and lower control limits shall be calculated per set of about 15 test specimens and indicated appropriately on the progress chart. Where the average strength of concrete shows a consistent increase or decrease from the design strength, the mix shall be redesigned. Acceptance of the work shall not be based on a single test result but on statistical basis such that the lower control limit calculated for a tolerance level of 1 in 15, for sets of 15 test results shall not be lower than the specified minimum design strength and the coefficient of variation shall not be

more than 10 per cent. For particulars about computation of concrete strength on statistical basis reference may be made to para N. 1.10. of Supplementary Notes. The work shall be taken to meet the specification requirements when the lower control limit is above the specified minimum structural strength and the stipulation regarding coefficient of variation is satisfied. Where these requirements are not met with or where the quality of the concrete or its compaction is suspected, the actual strength of the concrete in the structure shall be ascertained by carrying out tests on beams or cores cut from the hardened concrete. The minimum number of such beams or cores shall be 2 for every 30 cu.m. of concrete.

The results of crushing strength tests of those cores shall not be less than 0.8 times the corresponding crushing strength of cubes, where the height to diameter ratio of the core is 2. Where height to diameter ratio is varied, then the necessary correction should be made as follows for this variation in calculating the corresponding crushing strength of cubes -

The crushing strengths of cylinders with height to diameter ratios between 1 and 2 may be corrected to correspond to a standard cylinder of height to diameter ratio of 2 by multiplying with the correction factor obtained from the following equation -

$$f = 0.11 n + 0.78$$

where  $f$  = correction factor and  
 $n$  = height to diameter ratio

The corrected test results shall be analysed for conformity with the specification requirement on the same lines as indicated above in this para for cube/beam samples.

Where the core tests are satisfactory, they shall have precedence for concrete quality over the results of moulded specimens. The diameter of core shall not be less than 10 cm.

If, however, the tests on cores also confirm that the concrete is not satisfying 'the strength requirements, then the concrete corresponding to the area from which the cores were cut should be replaced, i.e., over an area extending between two transverse expansion joints at least where the defects could be isolated or over larger areas, if necessary, by taking additional cores and testing them.

**11. Design thickness for concrete roads** – The thickness of concrete roads shall be worked out as per IRC - 58 -1974 "Guidelines for the Design of Rigid Pavements for Highways".

## SUPPLEMENTARY NOTES

### **N. 1. Concrete**

**N.1.1. Desirable properties of pavement concrete** - For road work, the concrete should have sufficient workability to permit of thorough compaction, and adequate compressive and flexural strength; it should also be dense resistant to weather, capable of resisting the abrasive and impact action of traffic, finished with an even surface to give a good riding quality and provided with a surface texture such as to maintain a high resistance to skidding throughout its life.

**N. 1.2. Workability** - The workability of the mix should be just sufficient to enable the concrete to be compacted fully by whatever method is employed. It should not be higher than necessary for this purpose, as this will lead to segregation, surface laitance, difficulty in maintaining the concrete ' to its true profile on gradients and crossfalls, and a reduction in strength due to excessive water content. The workability required will depend very largely on the method of compaction employed.

### **N. 1.3. Strength**

**N. 1.3.1. General** - The quality of concrete is normally assessed by measuring its compressive strength because this is the easiest and most convenient test to make. For pavings, however, it is the flexural strength rather than the compressive strength of concrete which determines the degree of cracking and thus the performance of the road, and it is imperative to control the quality on the basis of flexural strength. Wherever direct flexural strength tests are not possible, this may be done indirectly through correlation of compressive and flexural strengths. As recommended in para 4.1.2, for each particular case, therefore, correlation between the two has to be established at the laboratory mix design stage, for the particular materials involved. In case quality of concrete is to be controlled through compressive strength tests the correlation will apply so long as the quality of materials remains unchanged.

**N. 1.3.2. Variation in strength** - When adopting a concrete mix to provide a given strength at a certain age, variations in strength may occur even from batch to batch. These are caused by variations in quality of cement, in the grading of aggregates, in batching, in the degree of compaction, and in weather conditions. Good control during the manufacture and placing of concrete will, therefore, reduce the variation in concrete strength.

**N. 1.3.3. Variation in strength due to variation in quality of cement** - Investigations have shown rather wide variations in concrete strengths at early ages on account of variations in



the quality of cement used. The relevant Indian Standard Specifications ensure minimum strength requirements, but do not control variations above the minimum and the strengths of cement commercially supplied can vary substantially. Concrete mix should, therefore, be designed using representative samples of cement actually to be used in the construction. In case the strength of subsequent cement supplies varies substantially, the mix should be redesigned.

**N.I.3.4. Variation in strength due to degree of control** - A minimum cube crushing strength for the concrete of not less than  $280 \text{ kg/cm}^2$  at 28 days has been generally found to give a flexural strength of  $40 \text{ kg/cm}^2$ ; the average strength for mix design will be higher than this as noted below. As the inherent variability of concrete will result in occasional strengths, which are higher and lower than the normal range of variability, it is reasonable to allow a small proportion of the results to fall below the specified minimum value. The present Code allows this proportion to be up to 1 in 15 with a permissible coefficient of variation of not more than 10 per cent, and requires the degree of quality control to be at least 'good'. In order to meet these requirements, the mix should be designed to give a mean flexural strength of  $47 \text{ kg/cm}^2$  mean compressive strength of  $330 \text{ kg/cm}^2$  at 28 days. If the control is inadequate so that the degree of quality control is less than 'good', the mean strength will need to be higher, to ensure compliance with the minimum requirements; this will necessitate the use of more cement, and such mixes, apart from being more costly, are more liable to produce shrinkage cracks, especially if the curing is inadequate.

**N. 1.4. Degree of Compaction** - Particular attention should be paid in constructing concrete roads to the methods of compacting the concrete. It is of the utmost importance from strength consideration that maximum compaction should be achieved without segregation. When high efficiency vibrating or other machines are used to compact the concrete from the top surface only, very little trouble would normally be experienced with concrete layers up to 250 mm thick, provided the concrete has adequate and uniform workability. With commercially available screed vibrators of low amplitudes, this thickness is of the order of 125 mm. With inadequate vibration or where the compacting effort does not correspond to the thickness to be compacted in one layer for full compaction, the lower layers of the concrete will suffer from honeycombing due to presence of excess voids. The presence of 5 per cent voids in the concrete will reduce the strength from that of fully compacted concrete

by about 30 per cent and the presence of 10 per cent voids will reduce the strength by 60 per cent. The engineer should, therefore, satisfy himself that the concrete gets properly compacted throughout the depth. Careful observation of the side surface of concrete after the removal of form work will help in identifying the honey - combed area to some extent. In case of doubt, breaking of a trial slab or drilling of cores may be resorted to for confirming the efficacy of the vibrating effort.

**N. 1.5. Durability** - Chemical attack on concrete in roads is not normally serious enough to warrant particular precautions. Where, however, soils are impregnated with deleterious salts in injurious amounts, protection of concrete from direct contact with such soils may be achieved by providing a suitable capillary cut -off as described in para 6.4. Where sulphate attack is probable, depending on the degree of severity, sulphate resistant -cements or portland blast furnace slag cements or portland pozzolana cements or cements with pozzolanic admixtures such as burnt -clay pozzolana or fly ash may be used. In all cases concrete shall be well compacted, strong and dense. Pozzolanic admixture to cement or portland pozzolana cement may also be found useful in areas where alkali -reactive aggregates cannot be precluded from use in concrete road construction.

**N. 1.6. Resistance to abrasion** - The resistance of concrete to abrasion is normally very high when good quality hard aggregates are used. Nevertheless, some engineers prefer to use two -course construction, the top course containing specially selected and therefore often expensive aggregate such as good quality granite or basalt. The use of rounded aggregate or aggregate which wears away at the same rate as the cement matrix in the top course, may in time tend to polish and produce a slippery surface. Besides, when the road is to be used by steel tyred or tracked vehicles, such as iron -tyred bullock carts, tanks etc., the use of certain types of aggregates encourages rapid abrasion. It has been established that with good quality concrete of an average compressive strength of the order of 450 kg/cm<sup>2</sup> (corresponding flexural strength being of the order of 50 kg/cm<sup>2</sup>) or greater, good resistance to abrasion can be secured with any of the better class aggregates. In the case of concrete of lower strength, the type of aggregate becomes progressively more important; and the best results are obtained by using a good, tough aggregate such as granite, basalt or trap. Results would not be satisfactory when comparatively brittle, materials such as flint are used.

**N. 1.7. Riding quality** - Producing regular surface of concrete is very closely connected with careful spreading, accurate setting and bedding of the side forms and standard of workmanship in constructing joints and in finishing. The concrete mix should be of uniform consistency and such that when screeded it holds up to cross falls and gradients without deformation, and yet is sufficiently workable at the edges of the slabs. The uniform spreading of the concrete with requisite surcharge that will ensure maximum density after compaction will minimize surface irregularities. The surface should be checked regularly with a straight edge 3.0 m long, and the permissible tolerance over this length should not exceed 3 mm. Alternatively, a wet surface profilometer may be used for continuous checking of the

surface. Great care should be taken in constructing joints so that the edges of concrete on the two sides of a joint are at the same level. It is only by careful attention to the standard of surface finish from the commencement of construction that good riding quality can be obtained.

**N.1.8. Surface texture** - It is not possible at present to define the surface texture of a concrete road in terms of its durability and resistance to skidding. It is, however, known that the concrete should not be worked to such a degree during compaction that laitance appears on the surface, and that, given well -proportioned concrete, a satisfactory surface can be produced by standard methods of compaction.

**N. 3.9. Use of admixtures** - An admixture is a material added in very small quantities to a concrete mix to improve some of its desirable properties. It may be understood that an admixture is no substitute for a well produced, adequately compacted and well placed concrete. Three types of admixture are worth considering here, namely, air -entraining agents, accelerators and retarders. The use of certain admixtures to entrain air in concrete is stipulated in some specifications. The air is entrained in the form of numberless discrete and microscopic bubbles evenly distributed through the mass and normally occupying in total from 3 to 6 per cent of the volume of the concrete. Such concrete is better resistant to the action of frost, less liable to segregation and bleeding and more workable than concrete with no air -entrainment. The strength can be restored to the original value by small adjustments in the mix proportions. Because of increased workability due to incorporation of air -entraining agent, the water -cement ratio can be somewhat lowered so that the loss of strength due to air entrainment is compensated. Whilst air entrainment does not appear to be necessary in most parts of India to increase the frost resistance of concrete in road slabs, as in other countries, it may have advantages, by virtue of the greater cohesion and workability it develops, in facilitating the production of a good riding surface and in reducing flow on gradients and crossfalls. Pozzolanic admixtures such as burnt clay puzzolana could also be employed for conditions explained under "Durability" or for other reasons subject to satisfactory prior testing of the resulting concrete. In cold weather concreting calcium chloride in small quantity is sometimes used to accelerate the development of strength. Calcium chloride should however be used where there is no steel reinforcement in the concrete. The quantity of calcium chloride that can be used in concrete for the purpose is given in para 9.15.

Sometimes, when concreting is carried out in hot weather and the concrete tends to lose water rather fast due to evaporation, to offset the accelerated drying of concrete and to reduce the increased water demand, judicious use may be made of set -retarding and water -reducing admixtures. However, as some of these admixtures can cause undesirable secondary effects such as reduction in concrete strength, or increase in bleeding, etc., it is recommended that only such admixtures should be used in respect of which adequate prior experience or test data are available. Set -retarding admixtures include calcium ligno -sulphonate, various carbohydrates, other calcium salts and sulphates of zinc, aluminium,

copper and iron. These are generally used in quantities equivalent to 0.05 to 0.5 per cent by weight of cement. An addition of 0.05 per cent of sugar has been reported to be very promising as a set-retarding and water-reducing agent.

**N. 1.10. Computation of concrete strength** - This section has been prepared on the assumption that careful control will be exercised with constant supervision in respect of production and placement of concrete. The use of weigh batching, carefully graded aggregates, frequent moisture content determination on aggregates and regular control of workability are required to keep the variation in strength of the finished concrete as low as possible.

The requirement that not more than 1 in 15 of the test samples shall show flexural strength of less than 40 kg/cm<sup>2</sup> at 28 days and that the "coefficient of variation" shall not be more than 10 per cent can be examined as soon as a few (about 15) test results become available. The mean strength and the "coefficient of variation" or "standard deviation" of the available test results are calculated and the lower control limit (L.C.L.) worked out therefrom. To meet the requirements the lower control limit should not be less than the specified minimum strength. The standard deviation is calculated by summing the squares of the differences of individual test values, from their average, dividing by one less than number of values, and taking the square root of the result.

$$\text{Standard deviation } \sigma = \sqrt{\frac{\sum (x - \bar{x})^2}{n - 1}}$$

$$\text{Coefficient of variation, } v = \frac{100 \times \sigma}{\bar{x}}, \text{ and}$$

$$\text{Lower control limit (L.C.L.)} = \bar{x} - t\sigma = \bar{x} - t\bar{x}v/100$$

x = individual cube strength,

$\bar{x}$  = mean cube strength, and

n = number of specimens, and

t = tolerance level factor

Note – For assessment of quality control achieved on the basis of field strength test data, the values of tolerance level factor, t, for different tolerance levels and sample sizes are given below -

Sample size (no. of samples)	Tolerance level				
	1 in 10	1 in 15	1 in 20	1 in 40	1 in 100

10	1.37	1.65	1.81	2.23	2.76
20	1.32	1.58	1.72	2.09	2.53
30	1.31	1.54	1.70	2.04	2.46
$\alpha$ (infinite)	1.28	1.50	1.64	1.96	2.33

**Illustrative example** - Assuming, for example, that good control will be achieved and that a compressive strength of 280 kg/cm<sup>2</sup> corresponds to flexural strength of 40 kg/cm<sup>2</sup>, the mix can be designed on compressive strength basis for a mean strength of 330 kg/cm<sup>2</sup>. For not more than 1 in 15 cubes to show strength of less than 280 kg/cm<sup>2</sup> the standard deviation from such a mean will have to be not greater than 33 kg/cm<sup>2</sup>, i.e. a co-efficient of variation of 10 percent.

Taking compressive strength results of 10 field test cubes to be analysed statistically and adopting a tolerance level factor of 1.65 corresponding to a tolerance level of 1 in 15 for the sample size of 10 cubes -

Cube strength (x)	Difference from mean (x - $\bar{x}$ )	Difference <sup>2</sup> (x - $\bar{x}$ ) <sup>2</sup>
Kg/cm <sup>2</sup>	Kg/cm <sup>2</sup>	(Kg/cm <sup>2</sup> ) <sup>2</sup>
298.2	- 32.2	1037
302.3	- 28.1	790
330.4	-	-
351.5	21.1	445
330.4	-	-
344.5	14.1	199
274.2	- 56.2	3158
365.6	35.2	1239
362.6	32.2	1037
344.5	14.1	191
3304.2	Total	8076

Statistical parameters -

$$\text{Mean strength } \bar{x} = 3304/10 = 330.4 \text{ kg/cm}^2$$

$$(\text{Standard deviation})^2 = \frac{\sum (x - \bar{x})^2}{10 - 1} = \frac{8,076}{10 - 1} = 897 \text{ kg/cm}^2$$

Standard deviation ( $\sigma$ )

$$= \sqrt{\frac{\sum (x - \bar{x})^2}{n-1}} = \sqrt{897} = 30 \text{ kg/cm}^2$$

Coefficient of variation

$$v = \frac{100 \times \sigma}{\bar{x}} = 100 \times 30/330.4 = 9.1\%$$

Check -

L.C.L. (lower control limit) = mean strength – (tolerance level factor of 1.65 corresponding to permissible tolerance of 1 in 15) x (standard deviation)	= 330.4 – 1.65 x 30 = 280.9 kg/cm <sup>2</sup>
L.C.L. = mean strength – (tolerance level factor of 1.65) x (mean strength) x (coefficient of variation)	= 330.4 – 1.65 x 330.4 x 0.091 = 280.9 kg/cm <sup>2</sup>

In the above case, although one cube out of ten tested showed strength of less than 280 kg/cm<sup>2</sup>, it could be assumed that this was a freak result and the specifications were being met. as the L.C.L. is higher than the minimum stipulated strength of 280 kg/cm<sup>2</sup>. For other statistical forms, control charts etc. reference may be made to IRC special Publication No.11.

#### **N.1.11 Correction for the strength of cubes for ages greater than 28 days -**

The table below suggests correction of strength for cubes in kg/cm<sup>2</sup> to be deducted from the strength as determined by the test to the corresponding strength at 28 days for the purpose of guidance only. For cores, the correction may be taken as three -quarters of the tabulated figures.

Age in weeks	Correction to be deducted (kg/cm <sup>2</sup> )	
	Concrete of compressive strength 280 kg/cm <sup>2</sup> at 28 days	Concrete compressive strength 450 kg/cm <sup>2</sup> at 28 days
5	10.5	17.0
6	21.0	34.0
7	31.5	50.5
8	42.0	67.5
9	53.5	83.5
10	60.5	95.0
11	67.5	107.0
12	74.5	118.0
13	81.5	130.0

15	91.5	148.0
20	105.5	169.0
30	126.5	202.5
40 over	140.0	225.0

## N.2. Arrangement of joints

### N.2.1. Staggered joints

It has been observed that where transverse joints have been staggered on either side of a longitudinal joint, sympathetic cracking has often occurred in line with the joint in the adjacent slab; therefore, it is desirable that joints be constructed in line across the full width of the pavement.

**N. 2.2. Skew joints** - The use of skew joints increases the risk of cracking at the acute angled corners as described in N. 2.3. and may also tend to make the slabs move sideways. Thus transverse joints should, as far as possible, be at right angles to the edges of the pavement.

**N. 2.3. Acute-angled corners** - Wherever possible, acute -angled corners should be avoided in the layout of road slabs as the stresses due to wheel load become exceedingly high. Under the conditions of the corners warping upwards such that they are partially or fully unsupported, the stresses at the corners of various angles) calculated theoretically and expressed in terms of the stress at a right -angled corner, are approximately as follows -

Corner angle	Stress
90 <sup>0</sup>	100 percent
145 <sup>0</sup>	145 percent
50 <sup>0</sup>	210 percent

However, if acute -angled comers are unavoidable, as sometimes is the case at intersections, the corners should be strengthened by using adequate amount of reinforcement.

**N.2.4. Spacing of joints** - The spacing of transverse joints depends on several factors, the more important of which are the co-efficient of thermal expansion of the concrete, the temperature during placing, the frictional restraint of the subgrade to the movement of the slab, the thickness of the slab and the amount of the reinforcement. For unreinforced concrete slabs, the spacing of joints should be such as to obviate the formation of uncontrolled cracks, which would open and give rise to serious spalling. For reinforced slabs, the spacing of joints should be related to the weight of reinforcement so that the opening of hair cracks is effectively controlled.. Even if light reinforcement is used, joints can be spaced at much wider intervals, than in unreinforced slabs.

Expansion joints should be so placed that they will permit thermal expansion over a range of temperature from the lowest at which the slab between two consecutive expansion joints is laid to the maximum likely to be attained.

## **Recommended spacing of joints in rigid pavements for highways**

**a) Expansion joint spacings (based on CRR I study) (for 20 -25 mm wide expansion joints)**

Period of construction	Degree of foundation roughness	Maximum expansion joint spacing (m)		
		Slab thickness (cm)		
		15	20	25
Winter (Oct -March)	'Smooth'	50	50	60
	'Rough'	140	140	140
Summer	'Smooth'	90	90	120



(April -Sept)	'Rough'	140	140	140
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Note – See Table (c) for classification of different types of foundation layers according to degree of roughness.

**(b) Contraction joint spacings**

Slab thickness (cm)	Maximum contraction joint spacing (m)	Weight of reinforcement in welded fabric (for reinforced pavements only) (kg/cm <sup>2</sup> )
Unreinforced slabs		
10	4.5	-
15	4.5	-
20	4.5	-
Reinforced slabs		
10	7.5	2.2
15	13.0	2.7
20	14.0	3.8

Note – Where reinforcement is used in the form of mild steel bars, equivalent sectional areas corresponding to the sectional areas of the welded wire fabric should be employed.

**(c) Classification of different types of rigid pavement foundation according to their surface characteristics**

Surface roughness characteristics	Type of foundation
'Very Smooth'	Soil -cement, soil lime, etc, compacted sand and gravel. Smooth foundation covered with water proof paper.
'Smooth'	Compacted sand, gravel and clinker, stabilised soil. Rough foundation covered with water proof paper.
'Rough'	Water -bound macadam, soil gravel mix, rolled lean concrete, lime -pozzolana concrete, etc.

Spacing of longitudinal joints is determined by the lane widths to be provided in the carriageway. Where vibrating screeds are used, it shall be limited to 4 m.

## N. 3. Reinforcement

**N. 3.1. Basis of design** - The particular function of reinforcement in concrete slabs is to hold together fractured faces of the slabs after cracks have occurred. Adequate load transmission across the cracks is assured by interlocking action of the rough faces of the cracks, which also prevents infiltration of incompressible material in the crack. It does not appreciably increase the flexural strength of the unbroken slab when used in quantities, which are considered economical. Where the slabs are provided with adequately spaced joints to control cracking, reinforcement has virtually no function.

Reinforcement in concrete slabs is designed to withstand the tensile stresses caused by shrinkage and contraction due to temperature or moisture changes. The maximum tension in the steel across the crack is equal to the force required to overcome friction between pavement and subgrade from the crack to the nearest free joint or edge. This force will be the greatest when the crack occurs at the middle of the slab. Reinforcement is designed to withstand the tensile stresses when a crack develops at this location. For practical reasons, reinforcement is maintained uniformly throughout the length of short slabs, but on long slabs over 15.0 m in length, considerable savings can be effected by reducing the quantity of reinforcement in the portions of the slab near its end. This could be practical only where savings which might be effected by varying the weight of steel, would be great enough to pay for the additional labour and inspection required for handling different sizes of bar mats or fabrics and also where enough checks are provided for their placing in correct locations.

The amount of longitudinal and transverse steel required per 1m width or length of slab is computed from -

$$A_s = \frac{LfW}{2S}$$

where -

$A_s$  = area of steel in  $\text{cm}^2$  required per m width or length of slab.

$L$  = distance in between free transverse joints when the equation is used to calculate longitudinal steel or between free longitudinal joints or edges when figuring transverse steel,

$f$  = coefficient of friction between slab and subgrade,

$W$  = weight in  $\text{kg/m}^2$  of slab, and

$S$  = allowable working stress  $\text{kg/cm}^2$  in the steel.

When computing the value of  $W$  for use in this formula, concrete is generally assumed to

weigh  $2,400 \text{ kg/m}^2$  or  $24 \text{ kg/m}^2$  per cm of slab thickness. The value of  $f$  may range from 1 to 2, but 1.5 is the most commonly used value.  $S$  is usually taken as approximately 50 to 60 per cent of the minimum yield stress of steel.

**N.3.2. Types of reinforcement** - Extensive experience particularly in the U.S.A. indicates that small diameter bars or welded wire fabrics are more effective than the larger diameter bars of same required cross-sectional area, because they can be distributed more uniformly in the slab.

**N. 3.3. Location of reinforcement** - Since reinforcement in concrete slabs is not intended to contribute towards its flexural strength, its position within the slab is not important except that it should be adequately protected from corrosion. Since cracks starting with higher tensile stress at the top surface are more critical to the riding characteristics of the pavement when they tend to open, the general preference is for the placing of the reinforcement about 50 mm below the surface; this is usually accomplished by striking off the concrete such that the compacted layer is 50 mm below the final surface, placing reinforcement and then placing the remainder of the concrete. Reinforcement is often continued across dummy groove joints to serve the same purpose as tie bars, but at all full depth joints, the reinforcement is kept at least 50 mm away from the face of the joint or edge.

## **N. 4. Load transfer devices**

**N. 4.1. General** - Load transfer devices in concrete pavements are provided in the form of dowel bars.

**N. 4.2. Dowel bars** - Dowel bars are built as an integral part of transverse expansion joints. They are usually mild steel round bars of short length, whose half length is bonded into concrete on one side of the joint and its other half length is prevented from bonding with concrete; in addition, a recess is provided at the slip ends to accommodate the movement of the slabs through deformation of the premoulded joint filler during the expansion of concrete. Where they are used at full depth transverse contraction joints, this end recess is not provided. When used, they permit the joint to open and close but hold the slab ends on each side of the joint as nearly as possible at the

same level. The deflection of one slab under load is resisted by the other, slab (when connected by dowels), which, in turn, is caused to deflect and thus carry a portion of the load imposed upon the first slab. Where dowels are used across a transverse joint, they should be distributed over the full length of the joint. If a system of dowels functions perfectly and the load were concentrated exactly at the end of the slab, about 45 -50 per cent of the load would be transferred to the adjacent slab and each slab would be subject to about the same unit load stress. Since the wheel loads are not concentrated at the slab ends, it is not theoretically necessary to transfer exactly half of the load. Therefore, they are so designed that they will be capable of transferring 40 to 45 per cent of the gross controlling wheel load to the adjacent slab when the wheel is located next to the joint and well away from the edge of the slab.

In designing a system of dowels, it is first necessary to calculate the load transfer capacity of a single dowel. Since failure can occur either by shear or bending of the bar or by crushing of the concrete below the dowel bars, the strength is governed by the minimum capacity determined for the above conditions of failure. All of these are influenced by the width of the joint opening, allowable tensile and shear stress in the steel, diameter of the dowel bar, length of the dowel bar embedded in concrete and the allowable bearing stress on the concrete.

The second step in the design is to determine the load transfer capacity of a series of uniformly spaced dowels that make up the system. This is influenced by their spacing, the position in respect of the wheel load, load transfer capacity of a single dowel bar, pavement thickness, modulus of subgrade reaction (k) and centre to centre spacing of the wheels on the axle carrying gross controlling wheel load. The design procedure for dowels is indicated in I.R.C : 53 -1974 "Guidelines for the Design of Rigid Pavement for Highways". The following table reproduced from the Guidelines gives data in respect of dowel bars for thickness of concrete slabs usually employed in practice. From experience in various countries, it has been found that dowel bars do not provide very substantial advantage when thickness of the concrete slabs is less than 150 mm and hence their use in such cases is not usually recommended.

Design details of dowel bars

Design loading	Slab thickness (cm)	Dowel bar details		
		Diameter (mm)	Length (mm)	Spacing (mm)

4100 kg	15	25	500	200
	20	25	500	300

Note – the recommended details are based on the following values of different design parameters - permissible flexural stress in dowel bar = 1400 kg/cm<sup>2</sup> ; permissible bearing stress in concrete = 100 kg/cm<sup>2</sup> ; E value for concrete = 3.0 x 10<sup>5</sup> kg/cm<sup>2</sup> ; Poisson's ratio = 0.15 ; k – value of foundation = 8.3 kg/cm<sup>3</sup> ; maximum joint width = 20 mm; and design load transfer = 40 percent.

**N. 5 Tie bars** - Tie bars are used across the joints of concrete pavements wherever it is necessary or desirable to ensure firm contact between slab faces or to prevent abutting slabs from separating.

Tie bars may be used across longitudinal joints in slabs of uniform thickness. When used at such locations, tie bars are not required for structural reasons, their only function being to prevent the separation of the slabs, especially at fills or curves. When so used, they may be provided at longer spacings and permitted to take higher working stresses.

Tie bars are not designed to act as load transfer devices.

Tie bars are designed to withstand tensile stresses only. The maximum tension in the tie bars across any joint is equal to the force required to overcome friction between pavement and sub grade, from the joint in question to the nearest free joint or edge. The diameter and spacing of the tie bars are computed in the following manner -

The area of steel required per m length of joint may be computed by using the following formula -

$$A = \frac{bfW}{S}$$

in which

A = area of steel in cm<sup>2</sup> required per m length of joint,

b = distance between the joint in question and the nearest free joint or edge in m,

f = co-efficient of friction between pavement and subgrade (usually taken at 1.5),

W = weight of pavement slab per sq. metre in kg, i.e., 24 kg/m<sup>2</sup> per cm thickness, and

S = allowable working stress of steel in kg/cm<sup>2</sup>,

The length of any tie bar should be at least twice that required to develop a bond strength equal to the working stress of the steel. Expressed as a formula, this becomes;

$$L = \frac{2SA}{BP}$$

in which

L = length of tie bar

cm

S = allowable working stress in steel

kg/cm<sup>2</sup>

A = cross -sectional area of one tie bar

cm<sup>2</sup>

P = a perimeter of tie bar

cm

B = max. permissible bond stress

kg/cm<sup>2</sup>

The following table reproduced from the Guidelines gives design details of the tie bars -

**Design details of tie bars for central longitudinal joint of two -lane rigid highway pavements**

Slab thickness (cm)	Tie bar details			
	Diameter (mm)	Maximum spacing (cm)	Minimum length (cm)	
			Plain bars	Deformed bars
15	8	38	40	30
	10	60	45	35
20	10	45	45	35
	12	64	55	40
25	10	30	45	35
	12	45	55	40
	14	62	65	46

Note – The recommended details are based on the following values of different design parameters -

S = 1400 kg/cm<sup>2</sup>; B = 17.5 kg/cm<sup>3</sup> for plain bars and 245.6 kg/cm<sup>2</sup> for deformed bars; f=1.5; and W = 24 kg/m<sup>2</sup>/cm of slab thickness.

## N.6. concreting in cold weather

**N.6.1 General** - In temperate climates where freezing conditions may last only for a few days at a time, it is generally advisable and more economical to stop concreting operations rather than to adopt costly precautionary measures. Where, however, it is absolutely necessary to continue these operations and the high cost is considered to be justified in the interest of work, some or all of the following precautions should be taken, their extent

depending on the weather conditions and the degree of exposure envisaged -

- (i) Avoid the use of frozen aggregates;
- (ii) Warm the aggregates by means of indirect fire, or passing steam or hot air through the stockpiles;
- (iii) Protect the subgrade against frost or keep it warm by means of braziers so that it does not freeze when the concrete is laid on it.
- (iv) Use Rapid -Hardening Portland Cement or incorporate calcium chloride with the Rapid Hardening or Ordinary Portland Cements;
- (v) Heat the mixing water to 66°C; and
- (vi) Provide thick layers of straw or other insulating material on the surface as soon as the concrete is hard enough to sustain it without detriment. In case of delay in doing this, light covers like used gunny bags may be placed over the green concrete until such time as the insulating material can be supplied.

All these cold -weather concreting methods should be planned well in advance of expected low temperatures. The necessary special equipment and materials must be available at the work site before low temperatures occur.

**N. 6.2. Preparation for concreting** - Before concrete is placed in any form or around any reinforcement or on any surface, all ice, snow and frost should be completely removed and the temperature of all surfaces to be in contact with concrete should be raised above the freezing point. No concrete should be laid on a frozen subgrade or on one that contains frozen material.

**N. 6.3. Placement temperatures** - The laying of road pavement slabs with fresh concrete temperatures below about 5°C is undesirable because of very slow development of strength and the necessity for more prolonged curing; besides, with air temperatures around or below 0°C there is the danger of freezing. On the other hand, temperatures of fresh concrete exceeding 24°C are undesirable due to the higher water requirement, possible premature stiffening, difficulties in keeping the concrete moist development of internal stress and likelihood of cracking when concrete contracts on cooling. For most constructions, the desirable temperature of concrete at placement is between 15°C and 24°C

**N.6.4. Safe temperatures** - Generally, it is considered safe to maintain concrete at a temperature of not less than 15°C for 3 to 4 days or at a temperature of not less than 5°C for 7 to 8 days after casting. Air -entrained concrete containing 1 per cent of calcium chloride by weight of the cement requires only about half these periods of protection at these temperatures. At the end of the curing period, artificial heating should be discontinued and housings removed in such a manner that the fall in temperatures at any point in the concrete

will be gradual and will not exceed  $5^{\circ}\text{C}$ . in 24 hours. In case the temperature is allowed to drop too rapidly, excessive shrinkage will result in the surface and cause cracking.

The surface temperature of the hardened concrete should not be permitted to exceed about  $35^{\circ}\text{C}$  at any time during the curing period.

Record should be kept of the temperatures of outside air, enclosure and concrete surface.

**N. 6.5 Protection** - Arrangements for covering or housing newly placed concrete should be adequate to maintain in all parts of the concrete the recommended curing temperature and moisture conditions. Because heated air is likely to be dry, all concrete surfaces should be kept continuously moist.

An insulating layer for covering concrete may be conveniently composed of waterproof paper overlaid with a layer of straw and finally with a second layer of waterproof paper. Straw, 15 cm to 30 cm thick is likely to protect concrete in air temperatures as low as  $-4^{\circ}\text{C}$ .

**N. 6.6 Heating of materials** - For air temperatures not lower than  $-1^{\circ}\text{C}$ , the mixing water should be heated to bring the temperature of concrete at the mixer to between  $10^{\circ}$  and  $20^{\circ}\text{C}$ , for air temperatures below  $-1^{\circ}\text{C}$ , both the water and the fine aggregate should be heated to bring the temperature of concrete at the mixer to between  $15^{\circ}$  and  $24^{\circ}\text{C}$ . When air temperatures fall still lower, coarse aggregate should also be heated. When either aggregate or water is heated to a temperature in excess of  $38^{\circ}\text{C}$  loading of the mixer should be so earned out that cement does not come in contact with the hot materials. Aggregate should be heated in such a manner that frozen lumps are eliminated and that overheating or excessive drying is avoided. At no point should the aggregate temperature exceed  $100^{\circ}\text{C}$ , and the average temperature of an individual batch of aggregate should not exceed  $66^{\circ}\text{C}$ . Under no circumstances shall the concreting operations continue when the air temperature is less than  $-7^{\circ}\text{C}$ .

**N. 6.7 Accelerators and anti-freeze compounds** - Upto 2 per cent of calcium chloride may be added to the mix to accelerate hardening of concrete at low temperatures, provided no future injurious effects from increased alkali-aggregate reaction or sulphate attack are



envisaged. The U.S. Bureau of Reclamation uses 1 per cent of calcium chloride in much of its cold weather concrete. **The calcium chloride shall not be used when reinforcement is provided in the concrete.**

## Appendix A

### List of I.R.C. Standards referred to in the text

1. IRC. -19 -1977 Standard Specifications and Code of Practice for Wafer Bound Macadam.
2. IRC - 34 -1970 Recommendations for Road Construction in Waterlogged Areas.
3. IRC - 43 -1972 Recommended Practice for Tools, Equipment and Appliances for Concrete Pavement Construction.
4. IRC - 44 -1976 Tentative Guidelines for Cement Concrete Mix Design for Road pavements (for non -air entrained and continuously graded concrete) (First Revision).
5. IRC - 49 -1973 Recommended Practice for the Pulverization of Black Cotton Soils for Lime Stabilisation.
6. IRC - 50 -1973 Recommended Design Criteria for the use of Cement Modified Soil in Road Construction.
7. IRC - 51 -1973 Recommended Design Criteria for the use of Soil Lime Mixes in Road Construction.
8. IRC - 57 -1974 Recommended Practice for Sealing of Joints in Concrete Pavements.
9. IRC - 58 -1974 Guidelines for the Design of Rigid Pavements for Highways.
10. IRC - 59 -1976 Tentative Guidelines for Design of Gap Graded Cement Concrete Mixes for Road Pavements.
11. IRC - 60 -1976 Tentative Guidelines for the use of Lime Fly Ash Concrete as Pavement Base or Sub -base.
12. IRC - 61 -1976 Tentative Guidelines for the Construction of Cement Concrete Pavements in Hot Weather.
13. IRC - 63 - 1976 Tentative Guidelines for the use of Low Grade Aggregates and Soil - Aggregate Mixtures in Road Pavement Construction.
14. IRC - 68 - 1976 Tentative Guidelines on Cement Fly Ash Concrete for Rigid Pavement

Construction.

15. IRC - 74 –1979 Tentative Guidelines for Use of Lean Cement Concrete and Lean Cement Fly Ash Concrete as a Pavement Base or subbase.

16. IRC - SP - 11 – 1977 Handbook of Quality Control for Construction of Roads and Runways. (First Revision).

17. IRC - SP - 17 – 1977 Recommendations about Overlays on Cement Concrete Pavements.

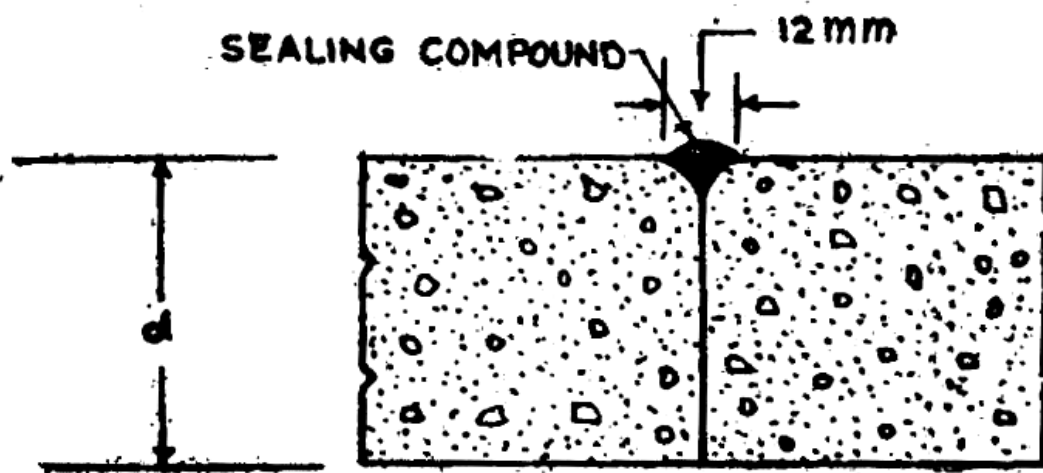


Fig 1 Plain butt joint (for longitudinal Warping and construction joints)

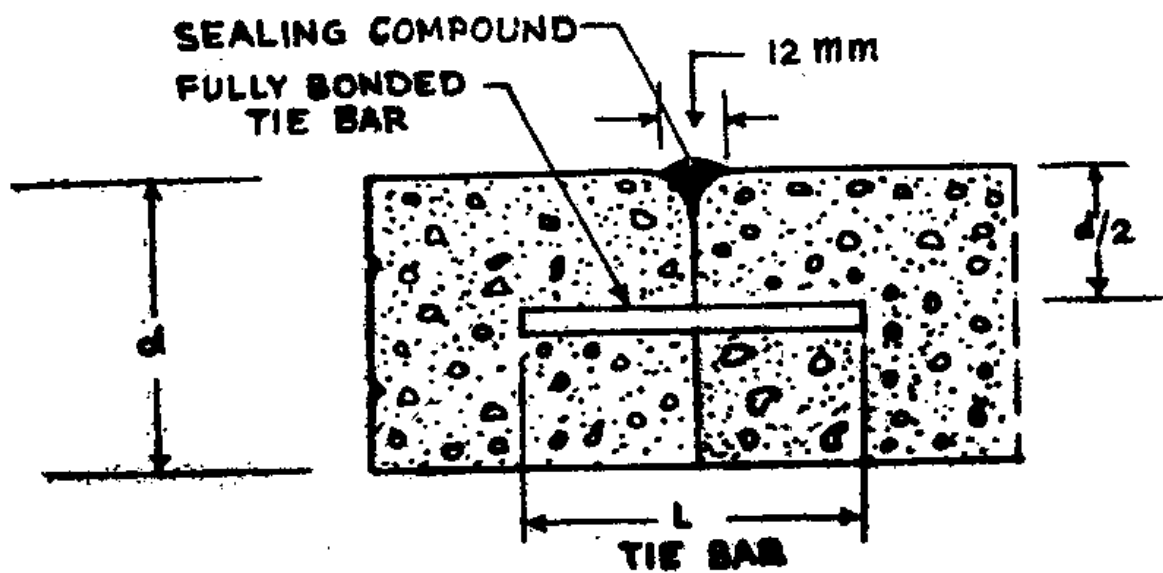


Fig. 2 Butt joint with tie bar (for longitudinal warping joint)

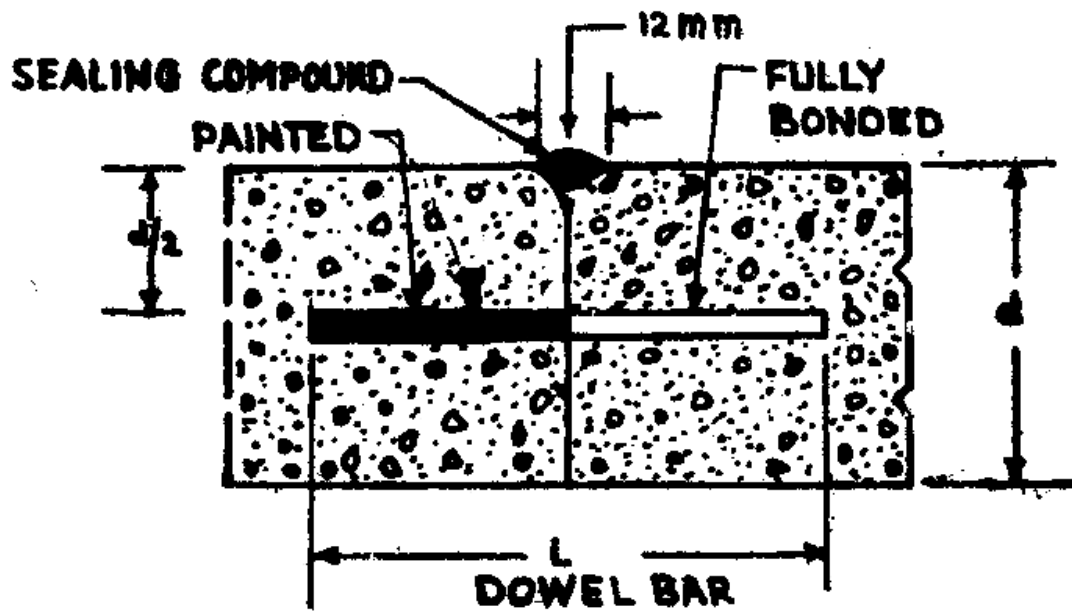


Fig 3 Butt joint with dowel bar (for construction joint )

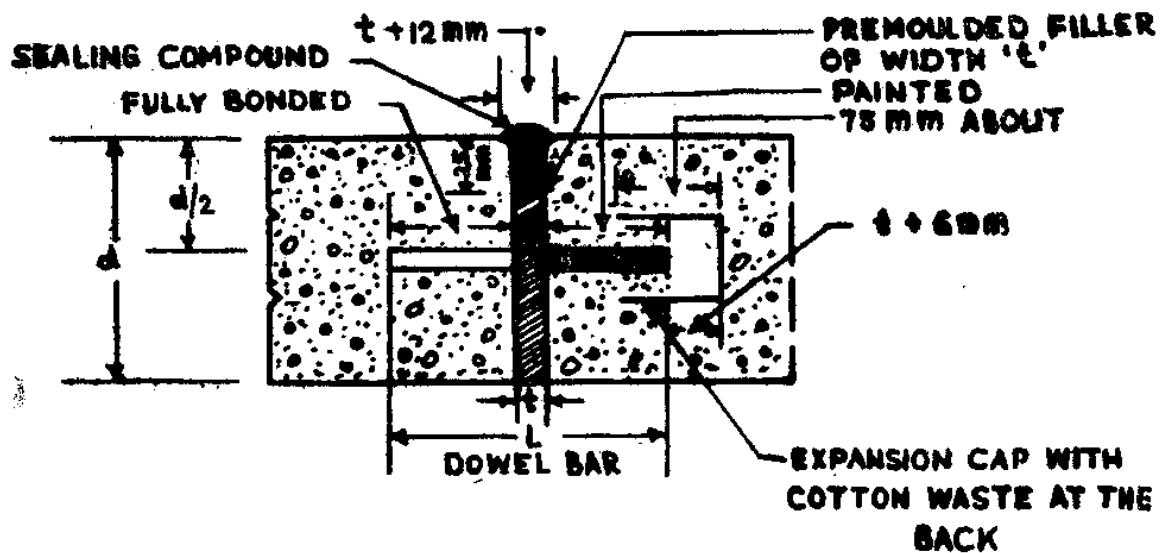


Fig. 4 Expansion joint with dowel bar

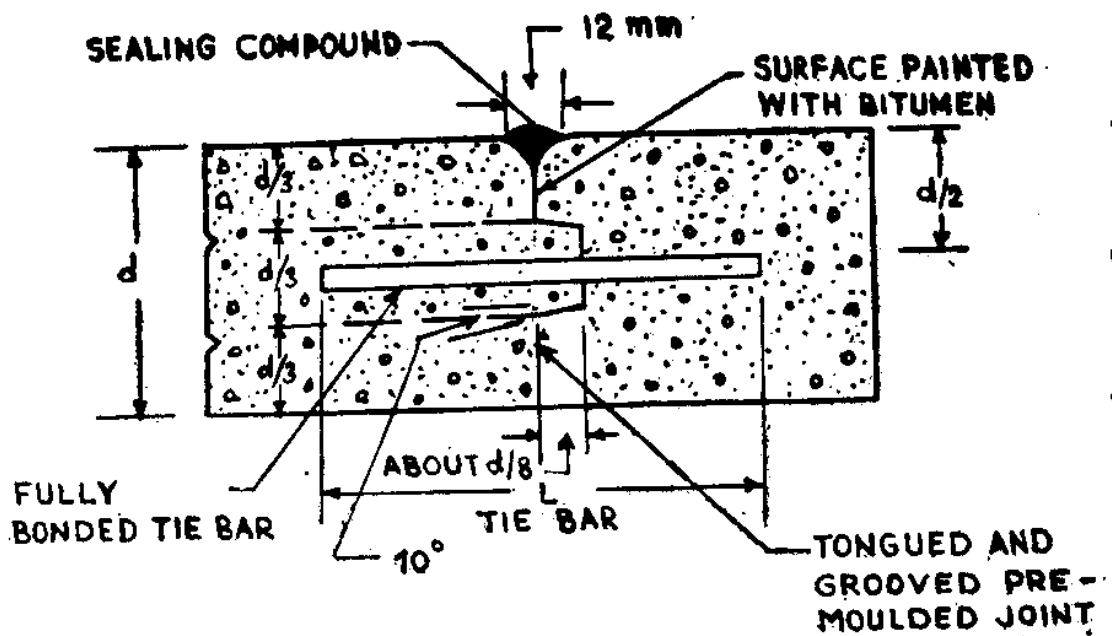


Fig 5 Keyed joint with tie bar (for longitudinal warping joint)

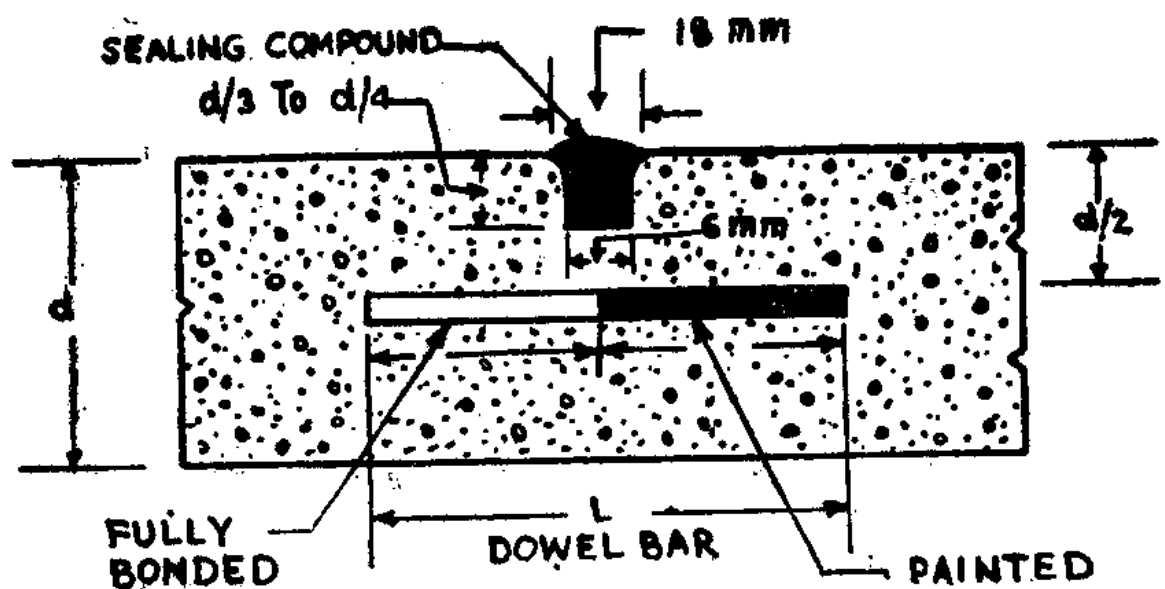


Fig 6 Dummy groove joint with dowel bar  
(for construction joints used with or without dowel)

- Note – (a) Maximum radius for rounding of corners of slab – 6 mm.  
(b) L – Length of dowel or tie bar.  
(c) d – Slab thickness  
(d) t = Expansion joint width/premoulded filler board width.

### Direct field adjustment chart for concrete mixes to counteract variations in compressive strength due to use of different quality cements and other factors

Owing to large variations in the quality of cement from different factories in the country, the site engineers at concrete works, having cement supply from different sources during the progress of work, have been experiencing serious difficulties to maintain the design strength of the concrete mixes. In many such construction works, facilities for redesigning the mixes with fresh consignment of cement are not available. Besides, such redesigning is time consuming. It may take some 4 -6 weeks to redesign the mix with supply of cement from new source. Keeping this in view, based on detailed laboratory investigations on cement concrete mixes using cements from different factories, a method has been developed, which envisages direct field adjustment of concrete mixes through alteration in the water -cement ratio and aggregate cement ratio with the use of a chart (Fig. C. 1).

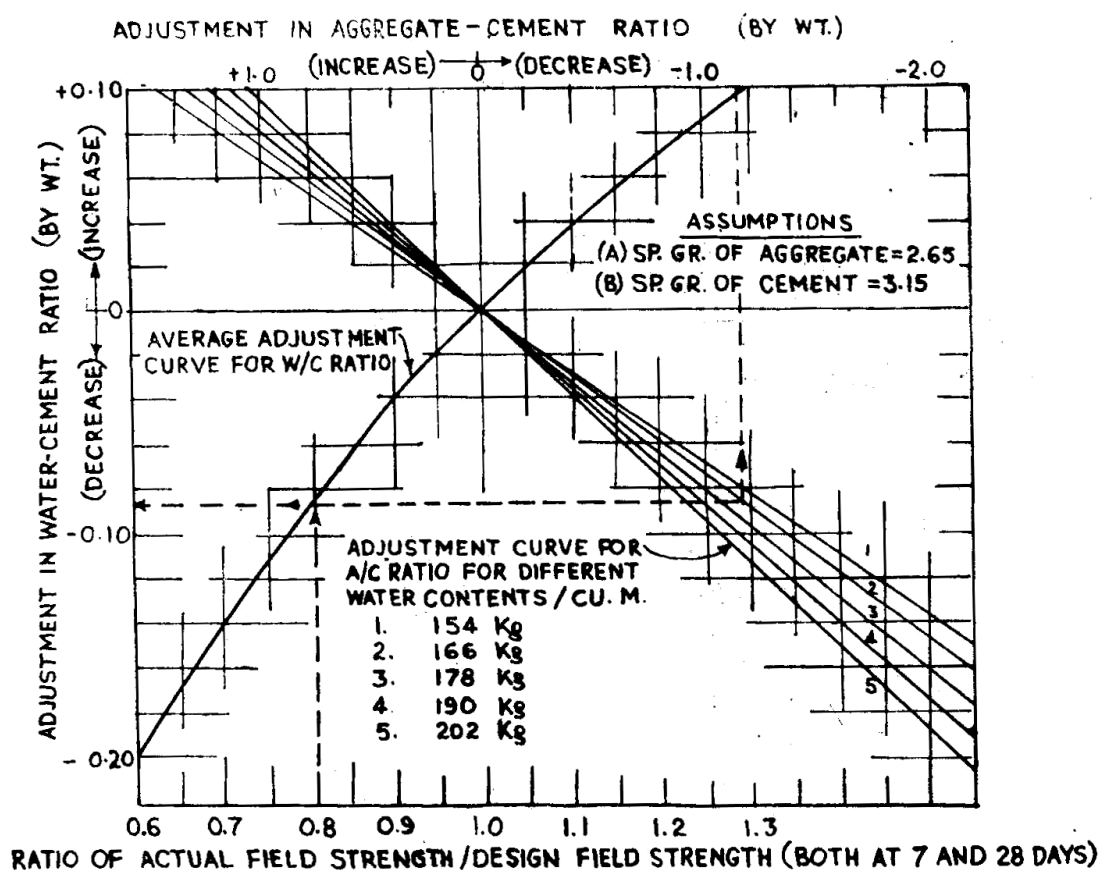


Fig. C. 1. Direct adjustment curves for cement concrete mixes using different Indian cements to counteract variations in compressive strength in the field

The adjustment chart is useful not only to counteract variations in compressive strength due to change in the cement quality, but also to effect suitable alteration in the mix which has not been yielding the desired strength due to other reasons including human (control) and climatic factors.

The aggregate -cement ratio adjustment curves have been drawn taking the specific



gravities of 2.65 and 3.15 for aggregates and cement respectively. If there is any marked difference in the specific gravities of either aggregate or cement, these curves should be suitably altered using Eqn. (1) or (2).

$$V = \left( W + \frac{C}{S_c} + \frac{1}{P} \cdot \frac{S}{S_s} \right) \frac{1}{1000} \quad \text{.....(1)}$$

$$V = \left( W + \frac{C}{S_c} + \frac{1}{1-P} \cdot \frac{A}{S_a} \right) \frac{1}{1000} \quad \text{.....(2)}$$

V = absolute volume of the wet mix (say, cu.m.) minus the volume of entrapped air

W = weight of water in kg per cu.m. of concrete

C = weight of cement in kg per cu.m. of concrete

A = weight of coarse aggregate in kg per cu.m. of concrete

S = weight of sand in kg per cu.m. of concrete

P = proportion (in decimal fraction) of sand in total aggregate determined on the basis of absolute volume, and

S<sub>c</sub>, S<sub>s</sub>, S<sub>a</sub> = specific gravities of cement, sand and coarse aggregate respectively.

Since the adjustments are given in terms of increments and decrements necessary, the chart can be used from the knowledge of the original mix alone. The use of the chart presupposes, besides knowledge of the present strength of the concrete with the original mix, that the original mix was correctly designed and that there have been no subsequent changes effected in the aggregate type, gradation or fractions. The chart is applicable for both the types of aggregates namely crushed stone and gravel.

**Method of using the chart** - It is presumed that to start with the site engineer will get the concrete mix designed in the laboratory for the required strength, on the basis of an average sample of cement, that he is likely to use. When during construction the source of cement supply changes, he should first obtain the concrete strength using fresh cement but keeping the mix proportions and water-cement ratio the same as earlier, if there is any difference in strength values with the use of fresh cement, the mix can be redesigned by using the chart given in Fig. C.1. The chart is applicable for both 7 and 28 days concrete strength.